RENEW NOW!
ONLY 2 ISSUES
REMAINING ON
YOUR SUBSCRIPTION.
SEE PAGE 129.

A R Q
17
WINTER
1999

THE JOURNAL OF THE
DEFENSE ACQUISITION
UNIVERSITY

ACQUISITION Review
QUARTERLY

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

VOL. 6 NO. 1

Major Douglas B. Bushey, USA Dr. Mark E. Nissen	**A Systematic Approach to Prioritizing Weapon Requirements and Military Operations Through Requisite Variety**	1
Lt Col Charles W. Pinney, USAF	**The USAF PEO/DAC/MAD Structure** *Successful Pattern for Future Weapon System Acquisition?*	21
J. Michael Hanratty Robert H. Lightsey Arvid G. Larson	**Open Systems and the Systems Engineering Process**	47
Margaret E. Myers	**An Investment-Based Approach for Managing Software-Intensive Systems**	61
William N. Washington	**"Subcontracting" as a Solution, Not a Problem, in Outsourcing**	79
Robert Graham Captain Eric Hoffman, USAF	**Reengineering the Acquisition Process** *A Quantitative Example of Acquisition Reform Working for the Air Force's Launch Programs System Program Office*	87

The ***Acquisition Review Quarterly*** is published quarterly for the Defense Acquisition University by the Defense Systems Management College Press, 9820 Belvoir Road, Suite 3, Fort Belvoir, VA 22060-5565. Periodicals Postage Paid at Fort Belvoir, VA and at additional mailing offices. Postmaster send changes of address to: Editor, ***Acquisition Review Quarterly***, Defense Systems Management College Press, 9820 Belvoir Road, Suite 3, Fort Belvoir, VA 22060-5565. For free copies, submit written requests to the above address. Articles represent the views of the authors and do not necessarily reflect the opinion of the Defense Acquisition University or the Department of Defense. ISSN 1087-3112.

The ***ARQ*** is available electronically on the DSMC Home Page at **http://www.dsmc.dsm.mil**

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	Winter 1999	Refereed Journal

4. TITLE AND SUBTITLE

Acquisition Review Quarterly (ARQ)
Vol. 6, No. 1

5. FUNDING NUMBERS

6. AUTHOR(S)

Numerous Authors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Defense Systems Management College
Attn DSMC Press
9820 Belvoir Road Ste 3
Ft. Belvoir VA 22060-5565

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Defense Acquisition University
2001 N Beauregard Street
Alexandria VA 22311

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicing acquisition professionals with relevant management tools and information based on recent advances in policy, management theory, and research. The ARQ addresses the needs of professionals across the full spectrum of defense acquisition, and is intended to serve as a mechanism for fostering and disseninating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decisions, and for maintaining a hign level of awareness regarding acquisition management philosophies.

14. SUBJECT TERMS

Sustems Engineering Process; Subcontracting; Software-Intensive Systems; Prioritizing Weapon Requirements

15. NUMBER OF PAGES

130

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

ACQUISITION Review QUARTERLY

Winter 1999
Vol. 6, No. 1

TABLE OF CONTENTS

OPINION

1 - A SYSTEMATIC APPROACH TO PRIORITIZING WEAPON REQUIREMENTS AND MILITARY OPERATIONS THROUGH REQUISITE VARIETY
Major Douglas B. Bushey, USA, and Dr. Mark E. Nissen
Diverse, global mission requirements and constraints on force modernization will affect the U.S. military in the 21st century. The theory of requisite variety can provide a systematic basis for prioritizing research, development, production, and operational activities to ensure warfighting effectiveness. An Army advanced warfighting experiment documents important results and considerations with respect to requirements determination, weapon system prioritization, and battlefield operations.

OPINION

21 - THE USAF PEO/DAC/MAD STRUCTURE
SUCCESSFUL PATTERN FOR FUTURE WEAPON SYSTEM ACQUISITION?
Lieutenant Colonel Charles W. Pinney, USAF
The Program Executive Office (PEO), who oversees the execution of a portfolio of related major programs, is organizationally positioned between the Program Manager and the Service Acquisition Executive. However, this complicates the relative roles and responsibilities with other acquisition officials—the Mission Area Directors (MADs) and the Designated Acquisition Commanders (DACs)—with mixed results.

OPINION

47 - OPEN SYSTEMS AND THE SYSTEMS ENGINEERING PROCESS
J. Michael Hanratty, Robert H. Lightsey, and Arvid G. Larsen
Acquisition managers in DoD too often rely on unique products provided by a single supplier at high non-competitive prices, and they have little opportunity to insert technology from other suppliers. Commercial manufacturers of large complex systems have successfully used the open-system approach to systems engineering to avoid these problems. DoD needs a rigorous systems engineering process in which resulting system designs more readily accommodate change to achieve cost, schedule, and performance benefits through multiple sources of supply and technology insertion.

LESSONS LEARNED

61 - AN INVESTMENT-BASED APPROACH FOR MANAGING SOFTWARE-INTENSIVE SYSTEMS
Margaret E. Myers
An investment-based management approach to the acquisition of software-intensive systems—especially those with extensive software components—requires command and control systems, automated information systems, and other information technology investments to keep us on the leading edge of both the Revolution in Military Affairs and the Revolution in Business Affairs.

TUTORIAL

79 - "SUBCONTRACTING" AS A SOLUTION, NOT A PROBLEM, IN OUTSOURCING
William N. Washington
The success of contracting has increasingly become dependent on subcontracting. Problems with subcontracting include loss of control and smaller-than-anticipated profits. Performance and comparability measurements can be used to monitor contractor performance and/or adjust the contract to reflect current pricing for performance.

TUTORIAL

87 - REENGINEERING THE ACQUISITION PROCESS
A QUANTITATIVE EXAMPLE OF ACQUISITION REFORM WORKING FOR THE AIR FORCE'S LAUNCH PROGRAMS SYSTEM PROGRAM OFFICE
Robert Graham and Captain Eric Hoffman, USAF
The Air Force Launch Programs System Program Office "reengineered" the cycle time for contract proposals—using acquisition reform tools and techniques—by developing a contractor/government Integrated Product Team to define a new streamlined approach for changing existing contracts with a 63 percent reduction in cycle time.

121 - ARQ GUIDELINES FOR CONTRIBUTORS

125 - DSMC'S HOME PAGE

OPINION

A SYSTEMATIC APPROACH TO PRIORITIZING WEAPON SYSTEM REQUIREMENTS AND MILITARY OPERATIONS THROUGH REQUISITE VARIETY

MAJ Douglas B. Bushey, USA, and Dr. Mark E. Nissen

The 21st century U.S. military—being redesigned, developed and tested today—is driven by diverse global mission requirements and force modernization subject to fiscal constraint. The practical application of the theory of requisite variety is accomplished through development of an analytical framework for prioritizing force structure elements. It provides a systematic basis for assigning priority to research, development, production, and operational activities. Requisite variety ensures warfighting effectiveness subject to a variety of different mission requirements and budget constraints. The authors use a game-theoretic model to emphasize the importance of requisite variety in weapon system prioritization and operational decision making. They outline, define, and provide examples of three concrete approaches to increasing the variety available to a military commander—regulation, information, and variety catalysts. And they reinforce the distinction between qualitative and quantitative variety in military systems and operations. They further examine the framework through an Army advanced warfighting experiment, which leads to important results and considerations with respect to requirements determination, weapon system prioritization, and battlefield operations.

As it heads into the 21st century, the U.S. military is driven by two divergent factors (Figure 1): diverse global mission requirements, and force modernization subject to fiscal constraint. Regarding the first factor, the military continues to fulfill mission requirements around the world, and it must remain prepared to deploy, in force, literally at a moment's notice. Although there is no

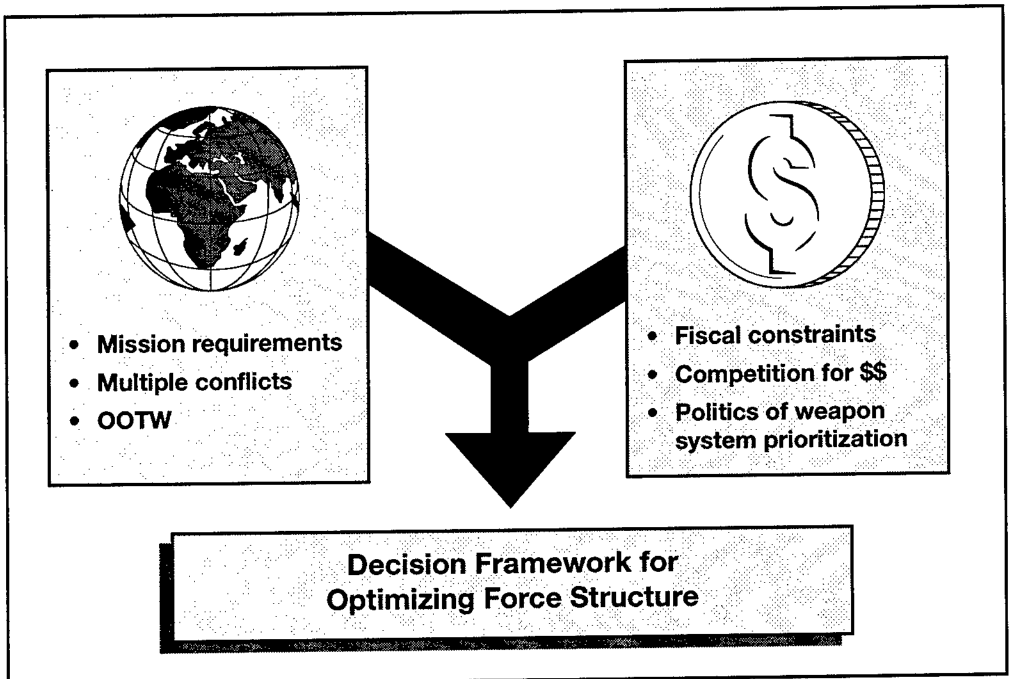


Figure 1. Motivation for the Study

longer a single, galvanizing threat such as the former Soviet Union, we observe an increasing likelihood of forces deploying to multiple, simultaneous regional conflicts. Missions are expanding to include operations other than war (OOTW), which can require a different set of skills and assets than those designed and used for intensive conflict. For example, the strict rules of engagement for peacekeeping missions could require a unique set of riot control weapons. A former Service Secretary has commented on this situation (West, 1997): "In the past, [we] trained primarily to fight and win large-scale conflicts; now we must prepare to meet a wider range of contingencies at all levels of the operational continuum."

The result is that U.S. military forces face greater demands than ever before, across a wide spectrum of threats that are globally dispersed yet temporally confined. In short, the requirements have never been so demanding and of such wide variety.

Moreover, existing military assets are aging and require modernization to catch up with the quantum technological advances of the past two decades, particularly those involving information technology. But modernization of a responsive global force represents an expensive proposition. This expense is compounded by the increased variety of the expanding military mission noted above. Concurrent with diverse and demanding mission requirements, the United States faces a severe fiscal constraint and has significantly decreased defense spending. Competition for dwindling defense dollars is intense, as modernization must compete with readiness, armor with air defense, the Army with the

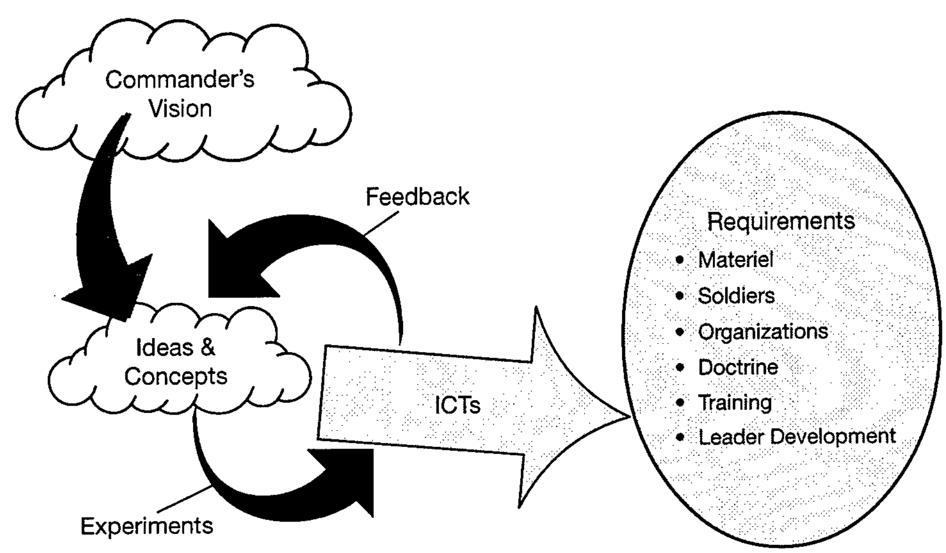
Navy and Air Force, and so forth. Further, the politics of weapon system prioritization are equally intense. As a result, the risk of misallocating scarce military resources to the wrong mix of systems has never been greater. The potential consequence of this situation is clear; when the need for warfighting arises, the correct mix and number of forces may not be available within the time frame required for decisive action.

This article demonstrates practical application of the theory of requisite variety through the development of a decision framework for prioritizing force structure. Although the scope of this article is quite broad and applicable to the entire joint warfighting community, we make the framework and associated concepts concrete by focusing on the Army, which arguably is most affected by expanding mission requirements such as OOTW. We will examine the current requirements determination process and conceptual doctrine the Army proposes to use in the 21st century. With this background, we apply the theory of requisite variety to develop a conceptual framework for analyzing the mix of weapon systems programs and operational forces. The framework provides a systematic basis for prioritizing research, development, production, and operational activities to ensure military warfighting effectiveness subject to a variety of different mission requirements (e.g., OOTW, peacekeeping, war) and severe budget constraints. We then examine the model by assessing this conceptual framework in terms of an Army advanced warfighting experiment, and then present conclusions and recommendations for the military leadership.

Current Requirements Determination Process

To address the complexities of 21st century warfare, the Army has implemented a new requirements determination process and developed unique concepts for land combat called Force XXI operations. The new requirements determination process investigates many promising advances in science and technology, in addition to meeting operational deficiencies identified through mission area analysis. The process depicted in Figure 2 begins with the training and doctrine command (TRADOC) vision, which is translated into required future operational capabilities (FOCs). FOCs are intended to provide a warfighting focus for the Army's science and technology investments. One set of FOCs is written for each of the Army's battle laboratories and encompasses the battlefield dynamics for which each lab is responsible. The battle labs (along with TRADOC combat developers) use integrated concept teams (ICTs) to transform FOCs into solutions across the domains of doctrine, training, leader development, organization, materiel, and personnel. These solutions are examined and tested through live, virtual, and conceptual warfighting experiments. Feedback from the experiments is used to further define and refine the product until a firm

"To address the complexities of 21st century warfare, the Army has implemented a new requirements determination process and developed unique concepts for land combat called Force XXI operations."



Source: Modified from U.S. Army TRADOC, *Requirements* (1996).

Figure 2. Army's Requirements Determination Process

requirement emerges (U.S. Army TRADOC, 1996). As noted above, the number and diversity of such firm and well-understood requirements continues to multiply.

The requirements determination process is designed to be flexible. ICTs include personnel from a broad spectrum of disciplines and have the potential to facilitate a smooth transition to the integrated product teams (IPTs) used to manage materiel programs. But the resources needed to purchase all materiel requirements are rarely there—especially in the quantities specified by commanders. The result is that key doctrine and tactics deemed necessary cannot be fulfilled. We believe there are numerous opportunities to leverage the theory of requisite variety during this process to help solve the problem.

Plans for Force XXI operations make numerous direct and indirect references to the need for variety in our forces. For example, they call for knowledge-based operations, which exploit information technology and leverage other technological opportunities to achieve a new level of effectiveness in joint warfighting, while minimizing exposure to casualties. They also call for soldiers themselves to become more versatile, capable of performing a number of different missions, often simultaneously. They emphasize multidimensional operations—attacking the enemy across myriad spectra, decisive operations, and even, simultaneously, humanitarian relief. Such features require commanders on the ground to be equipped with a wide variety of diverse weapon systems and modern assets, not just a large number of existing ones.

Unfortunately, the military has not articulated this need for variety well, and it has consequently suffered considerable criticism. For example, Army Force XXI operations have been criticized by some who believe the conceptual doctrine is too abstract, at the level of "Star Wars," and the Army has not adequately explained its vision for warfighting experiments to Congress (General Accounting Office, 1995). The theory of requisite variety provides the kind of intellectual foundation and approach to effectively articulate this need, as well as to assign priority to, quantify, and justify its integrated weapon systems, modernization plans, tactics, and doctrine.

Requisite Variety

The theory of requisite variety was developed through studies of complex system dynamics (Ashby, 1956). Researchers such as Ashby observed that as systems become more complex, the variety of their behaviors proliferates. Further, in order to control a complex system, the variety of responses built into the control mechanism must be at least equal to the variety of the system itself. In other words, the variety of the controller must equal or exceed that of the controlled, and the degree of variety sufficient to control a particular system is defined as requisite variety. Following Ashby (p. 208), only variety can control variety.

The theory of requisite variety has a direct military application. For example, it directly supports the Army concept of dominant maneuver. In the simple case shown in Figure 3,[1] the friendly commander serves as the control mechanism and the "enemy"(situation) represents the system to be controlled. Examples of this structure are coalition forces seeking to

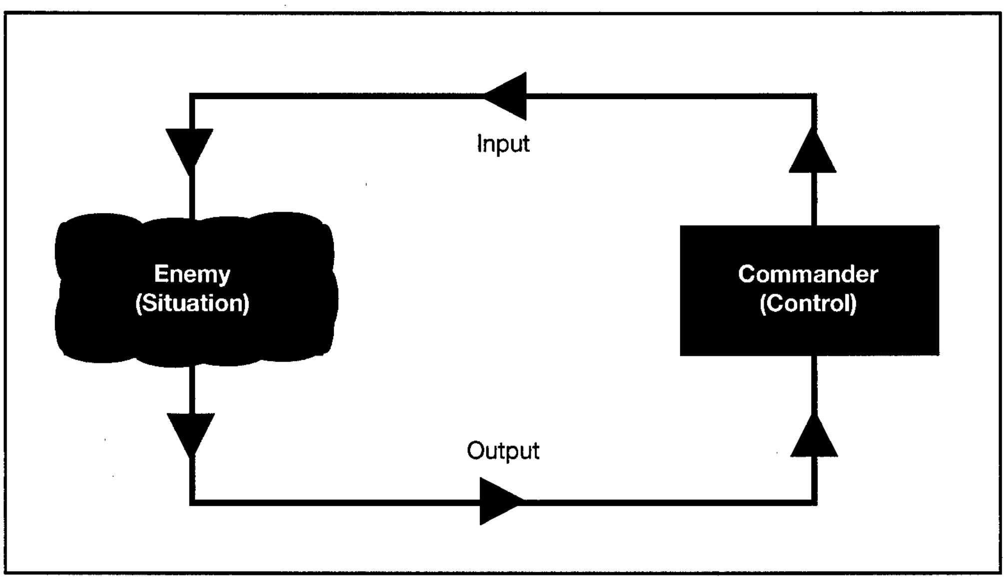


Figure 3. System Control

control Iraq's access to weapons of mass destruction, and peacekeeping forces working to control ethnic killing in Bosnia. Each action taken by the enemy is perceived by the commander, who uses the resources and options available to counter such actions and control the system. As the enemy grows in capability, the variety of available actions proliferates. To control this increasingly capable enemy, as a minimum, the commander must at least be able to counter enemy actions. But to dominate the enemy, the commander requires a variety of weapons and tactics that exceeds the enemy's ability to make an effective, timely response.

We illustrate requisite variety in a game-theoretic context as shown in Table 1. Although this example is simple, the theory and practical application scale very well to support military planning and weapon system prioritization up to the Army level and beyond (e.g., the Department of Defense, the North Atlantic Treaty Organization, coalition forces). The friendly commander's courses of action (COAs) are listed on the left side of the table. In this example, they include an armor battalion (AR BN), an attack helicopter battalion (ATK HEL), and an air defense task force (AD TF) capable of defeating helicopters and tactical ballistic missiles. The enemy commander's COAs are listed along the top. They include an attack helicopter squadron (ATK HEL), a tank regiment (TK REG), a motorized rifle regiment (MR REG), and a tactical ballistic missile regiment (TBM). As noted above, there is no hard limit to the number of COAs and mix of participants (e.g., Army/Navy, U.S./foreign military, war/OOTW) that can be analyzed through this technique. We now describe the simulated battle or engagement outlined in Table 1.

Both commanders are assumed to be situationally aware (i.e., they can see the table) and the game-theoretic rules are as follows. The enemy is allowed to make the first move by selecting a COA, and thus, a particular column. The friendly commander, observing this selection, then chooses a COA in response (i.e., a particular row). Recent military experience is replete with examples of this "wait for the enemy to move" approach (e.g., Iraq invades Kuwait; Serbia seizes control of Bosnia). The outcome of the encounter is determined by the intersection of the selected row and column and is represented in the table by bold, italic letters. Let's say, for example, that if the outcome is ***a,*** the friendly commander wins the engagement. If it is not ***a,*** the friendly commander loses.[2] Clearly the specific

Table 1. Matrix Model 1 of Ashby's Law

	ATK HEL	***TK REG***	***MR REG***	***TBM***
AR BN	b	***a***	c	d
ATK HEL	c	c	***a***	b
AD TF	***a***	b	b	***a***

table entries would vary for each theater of war or operations.

It is straightforward to show in Table 1 that the friendly commander possesses requisite variety to control the enemy. If the enemy moves first with attack helicopters (ATK HEL), for example, the friendly commander can counter with his air defense task force (AD TF). Similarly, if the enemy moves first with a tank regiment (TK REG), for example, the friendly commander can counter with armor (AR BN), and so forth. Regardless of the enemy COA, the friendly commander possesses sufficient variety to choose a COA and force the outcome to become ***a*** (therefore he can win), regardless of the enemy COA selected. And recall that the friendly commander even allows the enemy to move first. Thus, the friendly commander can dominate the theater because he possesses the requisite variety of forces and assets.

At first glance, this military application may appear obvious or even simplistic. A commander might state, for example, "Of course if you give me more tanks or more soldiers I will defeat the enemy; I will overpower him with numerical superiority." However, a careful distinction must be made between numerical superiority and the variety of options available to a commander. Numerical superiority, or quantitative variety, is just that—the number of soldiers, number of weapon systems or other factors used to determine a superior force. This was long the basis of Soviet weapon systems prioritization. Particularly when projecting force abroad, however, numerical superiority cannot always be ensured.

Alternatively, the nature of requisite variety is more qualitative. It is less concerned with aggregate totals than the mix of different types and capabilities of soldiers, weapon systems, and tactics, as well as various configurations and temporal patterns in which they can be employed. Thinking back to the Gulf War, for example, most experts seem to agree that satellite reconnaissance, broadband communication, fast armored maneuver, and Patriot air defense proved to be more instrumental to decisive victory than the number of tanks and soldiers in theater. Indeed, Gulf War experience supports our arguments by suggesting that the commander with a sufficient mix (i.e., requisite variety) of COAs can even defeat an enemy with numerical superiority.[3] This point is further illustrated through the simulated battle or engagement outlined in Table 2. This time the friendly commander has greater numerical quantities of some weapons than before (i.e., greater quantitative variety): two armored battalions and two infantry battalions. However, his qualitative variety has actually decreased because he no longer has an attack helicopter battalion or air defense task force. Now the table shows the friendly commander can no longer control the situation 100 percent of the time. For instance, the enemy can choose two COAs—attack helicopters (ATK HEL) and tactical ballistic missiles (TBM)—and force the outcome to be something other than *a* (i.e., force the friendly commander to lose the engagement). Despite having greater numbers of armor and infantry, the friendly

"Thus, the friendly commander can dominate the theater because he possesses the requisite variety of forces and assets."

Table 2. Matrix Model 2

	ATK HEL	TK REG	MR REG	TBM
AR BN	b	*a*	c	d
AR BN	b	*a*	c	d
INF BN	c	b	*a*	c
INF BN	c	b	*a*	c

commander lacks the requisite variety to counter and control the enemy.

Clearly, the concept can subsume Army operations to include joint warfare. For example, ADM Joseph Prueher, Commander-in-Chief, U.S. Pacific Command, recently made an indirect reference to requisite variety (Prueher, 1996):

> ...each service (Army, Navy, Air Force) brings a unique capability to the battlefield. It is similar to a football team. You can't have a team with all fast receivers with good hands. In addition you need strong, relatively slow linemen, defensive specialists, and a quarterback. This is the nature and strength of joint warfare.

With this background, we turn to the question of how to determine requisite variety for a military force, putting the framework to practical use.

Applied Military Framework

Our scheme to operationalize the concept of requisite variety is based on some concrete, well-understood methods for increasing commanders' ability to dominate the enemy. Consider the relatively simple model outlined above, in which a commander is responsible for controlling a system. Figure 4 shows an expanded model of the system embedded in its environment (depicted by the rectangle that encompasses the situation). This rectangle is drawn with dashed lines to indicate that, in real life, the environment is fluid, rather than static. Highlighted in the model are three factors affecting a commander's variety of action: regulation, information, and variety catalysts.

Regulation

External factors exert forces on the system beyond the commander's control, and regulation can affect variety either positively or negatively. On the positive side, regulation (beyond the commander's control) can be used to limit the capabilities of current enemies or potential threats. International treaties (e.g., Strategic Arms Limitation Treaty, Nuclear Non-Proliferation Treaty), postwar disarmament (e.g., of Germany and Japan) and arms-inspection programs (e.g., in Iraq) represent examples of positive regulation. Notice

the subtlety of such regulation. It serves to augment the commander's variety, not by increasing his COAs, but by decreasing the variety required for him to control the enemy.

As noted above, the opposite, negative effect of regulation occurs when the commander's mission portfolio is expanded (e.g., to include OOTW). These effects actually increase complexity and therefore exacerbate the need for variety in the friendly system. So long as the United States continues to use military forces to counter natural disasters and conduct OOTW, such lack of system regulation increases the variety of missions the Army has to perform.

INFORMATION

Information can be used by the commander to reduce the uncertainty of a system. Figure 4 shows numerous enemy COAs flowing toward the commander. To begin an engagement, the enemy selects one of these COAs.[4] But until the commander can see or sense which COA is selected, he must consider and plan for every likely option available to the enemy. For example, the commander in theater must deal with the uncertainty of when, where, and how (even if) an enemy might strike. Shown as a funnel in Figure 4, information acts as a filter to reduce uncertainty (e.g., sensing enemy armor movements) and to expedite the proactive

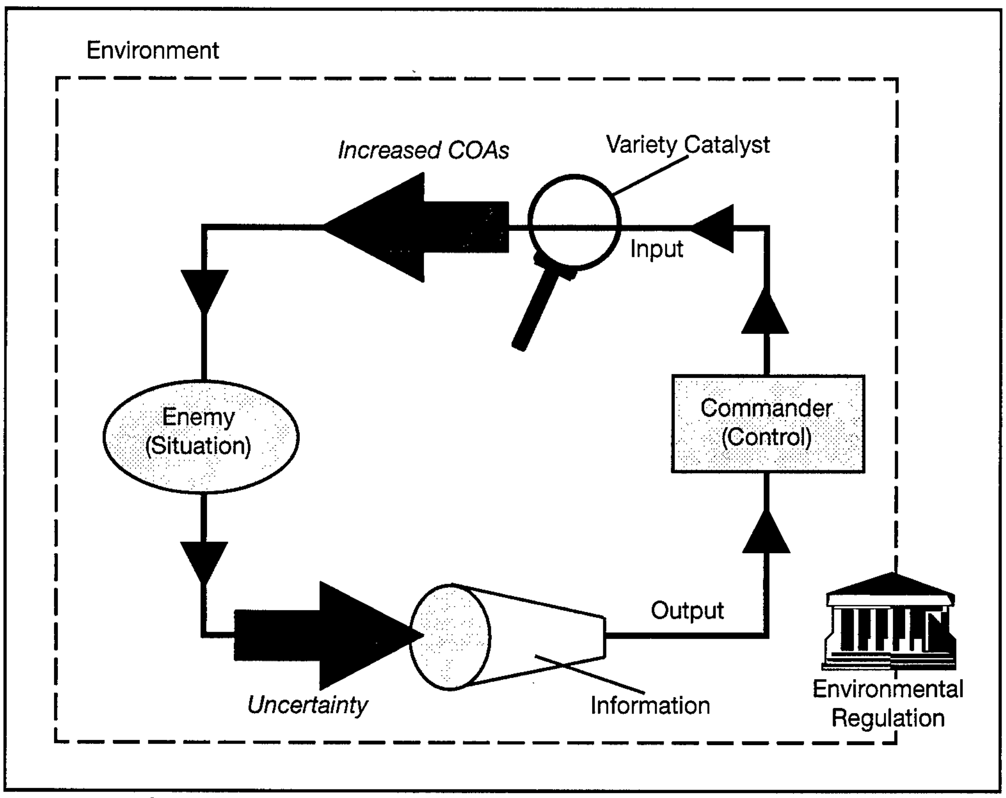


Figure 4. Framework for Providing Requisite Variety

use of counter actions available to the commander (e.g., long-range air mobile strikes). Indeed, such information dominance represents a key aspect of Force XXI operations.

Information also benefits the units and soldiers that are led by the commander. Some call this the "fog of war." To the soldier on the ground, it is the confusion or uncertainty of where he is on the ground, where the other units are located, and what is happening on the battlefield. Information—situational awareness—on the digital battlefield reduces this uncertainty, informing soldiers where they are, where their buddies are, and where the enemy is.

It is important to understand, however, that information does not reduce or limit the enemy's COAs. Rather, it reduces the uncertainty of the situation and helps the commander to anticipate and counter them responsively. This analysis points to command, control, communication, and intelligence (C^3I) assets as principal tools to exploit information dominance. Integrated C^3I assets reduce the time it takes to observe the enemy, orient friendly forces, and decide what action to take, for example.

"Information also benefits the units and soldiers that are led by the commander. Some call this the 'fog of war.'"

Variety Catalysts

The analysis above also points to mobility assets, which complement information by reducing the time required to take action. As with information, mobility has no direct effect on enemy COAs, but by increasing mobility, the commander's COAs (i.e., variety) increase. Thus, the reader should appreciate that relative variety is key to this analysis. Moreover, mobility represents an example of the most potent dimension associated with this framework: variety catalysts. As depicted in Figure 4, variety catalysts directly increase the number of COAs available to the commander. They include changes in doctrine, training, organizations, leadership, personnel and materiel. Figure 4 shows a set of COAs flowing from the commander to the enemy. Variety catalysts, depicted as a magnifying glass, amplify the number and types of COAs and increase the commander's variety. As noted above concerning materiel solutions, there are two ways to catalyze variety: quantitatively and qualitatively.

Quantitative catalysts. Increasing quantitative variety means increasing the number of the same types of weapon systems, soldiers, or units. This method relies on massive force structures to overwhelm the enemy. It is not concerned with different types or kinds of weapon systems, but entirely with the quantities of each. By increasing the number of weapon systems, variety expands due to the increased number of combinations available to the commander. Consider ADM Prueher's football analogy from above. Quantitative variety is like a team fielding 22 players against the opponent's 11. Think of all the different combinations of pass routes available to the quarterback with nine wide receivers, for example.

While this time-tested focus on quantitative variety may appear attractive, it has two distinct disadvantages. The first is cost. In today's environment, the DoD has little chance for budget increases.

Rather, military commanders are now accustomed to making do with less. Even so, opportunities to increase quantitative variety are not limited to just "buying more stuff." Most notably in the combat service support domain, the effective number of weapon systems (e.g., measured by tactical aircraft sortie rates) can be increased by reducing repair time, decreasing mean time to repair, and similar logistical interventions. The second disadvantage is that numerical superiority does not directly translate to victory on the battlefield. Earlier we saw that the friendly commander, despite having superior numbers, could not completely dominate the engagement because he lacked the necessary attack helicopters and air defense assets. In many instances, quality, not quantity, is the dominant factor in theater.

Qualitative catalysts. Qualitative variety concerns the diversity of actions available to control the system (e.g., commander COAs). Returning to our football analogy, to increase qualitative variety, a team could recruit players with different skills. Some may be fast runners and catch well, while others are big, strong, and very effective on the line, with still others who may kick well, and so forth. Note also by analogy that modern-era strategies and play selections require all players to be smart and well-trained. The Denver Broncos won Superbowl XXXII despite having a relatively "small" offensive line, for example, in part because of the variety of effective plays it could execute. A different option is to recruit players that are multitalented, athletes able to play multiple positions and roles well (e.g., running backs who can throw passes, blocking receivers, quarterbacks able to run). Such multitalented players tend to be quite expensive, however.

Regarding military weapon systems, there are three primary approaches to increasing qualitative variety. The traditional approach is to build many different types of weapon systems (e.g., service-unique aircraft or trucks). This is analogous to recruiting specialist players with different skills. The use of current and developing space technologies, for example, opens up an entirely new set of options for the commander who can sense and observe from the ultimate "high ground." History shows that the disadvantage of this option is cost. Different, specialized weapon systems require unique inventories of spares, separately trained mechanics, idiosyncratic ammunition, and specialized operator skills, the life-cycle cost of which is relatively high.

"The use of current and developing space technologies, for example, opens up an entirely new set of options for the commander who can sense and observe from the ultimate 'high ground.'"

A second approach—adapted from commercial industry—is to design families of weapon systems. For instance, a Bradley chassis can be used not only for an infantry fighting vehicle, but also for an air defense artillery system, and the Army currently does this with the family of medium tactical vehicles, which share a common chassis but are available in different cargo variants (e.g., materiel handling, dump, tractor, wrecker, vans). Likewise, the Navy envisions its next generation of surface combatants (SC–21) in terms of a family of ships, much C^3I

software is now developed into product lines, and so forth. Each individual system in a family or product line has a mix of common and peculiar elements in this approach. But this approach also suffers some of the same limitations, in that specialized parts, mechanics, operators, and the like could be required for each peculiar portion in a system family or product line.

A third approach to increasing qualitative variety is through weapon systems capable of performing multiple missions. This is similar to recruiting a multitalented player. For example, one weapon supersystem could be developed not only to shoot artillery fire, but also to destroy enemy aircraft and have enough mobility and direct firepower to be used as an infantry fighting vehicle. This third approach differs from that above in that both the air-defense and infantry missions, for example, are accomplished by the same vehicle, whereas two similar-but-different vehicles (sharing common parts) are required in the family or product-line scheme above. This option also has disadvantages, for building complex weapon systems with multiple roles is difficult and sometimes costly. Not only does operation near the edge of the state of the art often greatly increase cost and performance risk, it can also have a deleterious effect on reliability. Norm Augustine described this as the Law of Insatiable Appetites: "The last 10 percent of the performance sought generates one-third of the cost and two-thirds of the problems." He continues (Augustine, 1983):

"A third approach to increasing qualitative variety is through weapon systems capable of performing multiple missions."

> Soon DoD will build an aircraft that is so expensive that it will have to be shared by the Services. The Air Force will use it for three days, the Navy for two, and the Army and Marines will use it half the time for the other two days of the week.

Another disadvantage is the risk that one of these super systems would be destroyed. One artillery round or even a simple software virus could knock out a considerable amount of firepower. It would be like our multitalented football player suffering an injury which prevents him from playing.

Other areas such as doctrine, organizations, training, and recruiting can also increase the qualitative variety of a military force. While they may not directly increase the number of COAs available to the commander, they magnify variety by enabling a commander to more efficiently use his resources. Continuing our football analogy, these latter areas would pertain more to the coaching staff, training facilities, and draft strategies than the football players themselves, but in a budget-constrained environment such as that faced by the DoD, one is compelled to investigate every viable opportunity, particularly those that increase variety at reasonable cost.

EXAMINATION OF THE FRAMEWORK

We have used the applied military framework to articulate three concrete

methods for increasing the commander's ability to dominate the battlefield: regulation, information, and variety catalysts. Clearly, all three alternatives can be combined to compound synergistic effects, but the optimal mix is dependent on the specific set of requirements (e.g., war or OOTW, desert or jungle, pre-positioning or amphibious assault) and subject to budgetary constraints. This applied military framework provides the analytical structure to objectively conduct the necessary requirements and tradeoff analyses.

The framework is examined by applying it to an Army advanced warfighting experiment (AWE). The intent is to analyze the exercise from the perspective of our requisite variety framework. The exercise, conducted from July to December 1995, was a general officer working group project sponsored by TRADOC. The goal of the exercise was to determine Force XXI requirements, structure, and conceptual doctrine for use in follow-on live and virtual exercises. We chose this particular exercise because it served as the foundation for many TRADOC Force XXI conceptual doctrine publications and research studies. The objective of the exercise was to build upon the early Force XXI concepts and produce:

- the division operations and organization manual for Force XXI units;
- the warfighting tasks and tactics, techniques, and procedures (TTP) for Force XXI units; and
- the how-to-fight manual for the experimental force (EXFOR[5]).

A major regional contingency set in the 21st century served as the scenario for this exercise. The friendly forces consisted of a Force XXI division (e.g., M1A2 tanks, M2A3 infantry fighting vehicles, LOSAT antitank systems, future scout vehicles (FSV), and *Comanche* helicopters). This notional division was assigned the dominant mission of the corps' decisive operation. The opposing forces consisted of a combination of high- and medium-technology enemy divisions (e.g., T72/T80 tanks, BTR 80 infantry vehicles, HIND D/E/F helicopters). It is interesting to note the opposing forces outnumbered the Force XXI division; that is, the "enemy" possessed superior quantitative variety.

"...the general officer working group recognized that without requisite variety, the Force XXI division would be unable to conduct decisive operations; that is, the division would not be able to dominate the battlefield."

The AWE supports many aspects of our conceptual framework. For example, the general officer working group recognized that without requisite variety, the Force XXI division would be unable to conduct decisive operations; that is, the division would not be able to dominate the battlefield. The lack of requisite variety in this exercise can be traced to two factors. First, using TRADOC vernacular, the Force XXI division did not have the "assured capabilities" required for the operation. Two examples involve mobility assets for the light brigade and air defense assets. The ideal plan of attack included the use of light infantry in combination with armor

forces. But the division lacked the airlift or truck capability needed to fully exploit this option. The resulting mobility differential made it difficult to synchronize infantry with armor and left infantrymen vulnerable to counter-attacks with no capability for self-extraction. In addition, the extended range of the operation left the division vulnerable to air attacks and surveillance. Because the Force XXI division lacked sufficient air-defense assets, the enemy could exploit this weakness. In other words, if the enemy chose this COA, the friendly commander did not have the requisite variety to control the situation.

Second, the corps operation plan prescribed tasks that limited how the 25th (Force XXI) Division intended to fight. For example:

- Corps planned fire strikes on the enemy's 15th Tank Division (TD) and 3rd Motorized Rifle Division (MRD) prior to the 25th Division contact with the enemy.

- Corps employed dynamic obstacles to fix the enemy's 15TD and 3MRD.

- Corps assigned an aviation brigade to attack the lead regiments of the enemy's 15TD and 3MRD.

This regulation from higher headquarters limited the options available to the friendly commander, because these actions were in his area of operations. The examples show that external regulation, in this case, reduced the number of COAs available to the friendly commander (i.e., reduced his qualitative variety). Our framework suggests that less (negative) regulation could reduce this effect. Further, (positive) regulation could reduce the complexity of missions the friendly commander is required to perform, thereby decreasing the variety of the situation to be controlled. For example, higher headquarters could have reduced the threat of enemy second-echelon divisions by conducting air strikes beyond the 25th Division's area of operations. The group of general officers deemed this point to be very significant; one of their key findings was that higher headquarters must reduce the prescriptive tasks dictated to subordinate units.

This examination of the AWE supports two important aspects of our framework. First, variety in the friendly force is important. Without requisite variety, for example, the 25th Division could not conduct decisive operations. Second, higher command levels must consider the impact of external factors and strive to regulate these factors. Constraining commanders on the ground, for example, can actually limit warfighting effectiveness.

Given these observations, one might surmise the 25th Division had an unsuccessful day on the battlefield, but this was not the case. The division was highly successful because of the information available. The general officer working group realized that information dominance was a valued commodity that had to be planned for and efficiently used to be effective. Integrated C^3I assets such as satellites, human intelligence, electronic warfare, and radar systems reduce the uncertainty of the enemy situation. This situational awareness was leveraged through the use of highly mobile assets (e.g., helicopters given quick attack missions) and long-range precision strikes to proactively

shape the battlefield and dominate the enemy. They attacked the enemy in numerous directions from dispersed locations. By integrating C^3I and mobility assets, the general officers achieved synergistic results. These assets allowed the 25th Division to attack in a variety of patterns by leveraging information.

In summary, the AWE involved all three aspects of our framework for providing requisite variety: regulation, information, and variety catalysts. This helps portray how the concepts associated with requisite variety and our analytical framework can be applied directly to the military, and it highlights key elements of their use and utility in support of Army experiments involving its ideas for warfare in the future: Force XXI. This examination of the framework also reinforces the distinction between qualitative and quantitative variety and shows how even a numerically inferior force can prevail using regulation, information, and variety catalysts from the framework. In essence, we see that variety can serve as a proxy for military efficacy and provide some capability for explanation and prediction of differential results on the battlefield. Thus, our framework for requisite variety provides a language of constructs and method of analysis for robust and detailed effectiveness studies. And when combined with the many current techniques for cost analysis, this framework supports a novel, systematic approach to prioritizing weapon system requirements and military operations through requisite variety.

Conclusions

The analytical framework we have introduced supports a systematic approach to prioritizing weapon system requirements and military operations through requisite variety. This framework takes Ashby's Law, a relatively simple but underused theory, and applies it directly to the military. It shows that complex systems, including battles and engagements, can be evaluated through requisite variety, and the framework provides analytical constructs and guidelines for using variety as a proxy for, or predictor of, military efficacy. The military can first use the framework as a diagnostic tool to analyze the variety of the system. For example, it can help assess what threats are to be faced and the diversity of missions that are to be performed, then help identify possible solutions using the framework to maximize the operational effectiveness of forces through the requisite variety construct. Cost can then be weighed against the possible solutions.

"The analytical framework we have introduced supports a systematic approach to prioritizing weapon system requirements and military operations through requisite variety."

Further, the framework provides a common vocabulary to explain weapon requirements and the concepts of Force XXI to both Congress and the warfighters on the ground. It helps to answer many important and timely questions. For example, why is the military spending millions of dollars on high-tech equipment to digitize the battlefield? Why is the Army developing conceptual doctrine that seems

more suitable for Luke Skywalker than Sergeant York? Our use of requisite variety can improve the quality of answers provided to Congress, the soldiers, and other concerned stakeholders.

Although the concept of variety may appear intangible, the analytical framework described in this paper outlines three concrete approaches to increasing commanders' variety for battlefield domination: regulation, information, and variety catalysts. Each of these has distinct advantages and disadvantages. Optimally, a combination of the three alternatives should be considered for their synergistic effects, and when cost is combined with variety (as a proxy for effectiveness) in the equation, this framework provides the analytical structure necessary to objectively prioritize weapon systems and evaluate military operations.

"Our use of requisite variety can improve the quality of answers provided to Congress, the soldiers, and other concerned stakeholders."

RECOMMENDATIONS FOR THE MILITARY

This work leads us to six recommendations for the military.

Incorporate variety as a factor. The most significant finding of this study is that variety can be a useful factor for prioritizing requirements for the future operational forces of the U.S. military. We have seen that future military forces face a diversity of threats and missions in a global environment with unprecedented complexities. The theory of requisite variety reveals that in order to control such complex systems, the amount of variety in the control mechanism must equal or exceed that of the system being controlled. We recommend that each military service move to directly apply variety constructs such as regulation, information, and variety catalysts in its requirements determination process (especially during mission area analysis and analysis of alternatives). TRADOC should combine variety with cost as primary factors for prioritizing alternative weapon systems and force structures. All stakeholders including ICTs, IPTs, battle labs, and warfighters need to understand the concept of requisite variety.

Aggressively pursue intelligence on future threats. During the Cold War, the United States had very robust intelligence efforts to gain and interpret information about the Soviet Union. However, as defense spending has dwindled, so have these intelligence efforts. The United States should continue to pursue robust intelligence efforts focused on determining valid threats. Just as situational awareness decreases the uncertainty of the enemy situation to the friendly commander on the ground, identifying strategic threats can reduce the uncertainty at the national level. Without these intelligence efforts, it will be difficult to measure the amount of variety we need. The potential consequence is not having the correct mix of forces on the future battlefield.

Prioritize weapon systems. Given current financial constraints, the short-term military requirements should focus on C^3I and mobility systems. Such assets appear to provide the best variety-to-cost ratio and may represent a requisite-variety bridge to 21st century warfare. As illustrated in the AWE, information reduces uncertainty in the system, and

mobility complements situational awareness to increase the variety of action for friendly forces. Modernization of other weapon systems, such as multirole fighting vehicles, can further increase force variety, but this approach portends to be quite costly. With the quality of intelligence assets that exist, the military can make great strides by simply re-engineering the process of obtaining and distributing information. Notice we do not argue for building all intelligence systems and no action systems. But neither should we neglect intelligence to support weapon system modernization. Either way, by putting all our eggs in one basket, we risk not having the requisite variety to conduct decisive operations.

Continue joint warfare. Using the capabilities of all the Services in joint warfare is an excellent, low-cost approach to increasing variety. The United States should continue to train and fight as a joint team, and efforts should be made to increase the connectivity of weapon systems and doctrine to achieve synergistic results with the expanding NATO and potential coalition partners. The variety of weapon systems in current inventories and arsenals of allied nations is substantial, and it augments our ability to attack and defend across multiple dimensions from either dispersed or close-proximity locations on the battlefield.

Reduce higher headquarters' prescriptive tasks to subordinate units. Prescriptive tasks from higher headquarters negatively regulate commanders on the ground and limit their warfighting effectiveness. We observed this phenomenon with the 25th Force XXI Division. Following the technique of empowerment, higher headquarters should focus on what the requirements are, not how to perform them, and explicitly decide whether and how much to limit commanders' variety in theater.

Continue variety research. Our final recommendation is to continue this line of research to enhance and refine the framework developed in this paper. Toward this end, four topics for further study appear to have merit:

- Investigate alternatives to model and quantify the factor of requisite variety.
- Examine what impact requisite variety has on logistics in terms of life-cycle costs, schedule, and performance.
- Research different possibilities for variety catalysts.
- Explore how the conceptual framework for providing requisite variety can be applied to a weapon system program.

Research represents a prudent approach to developing new knowledge—especially when compared to trial and error on the battlefield—and the application of requisite variety to weapon system prioritization appears to be a timely, practical, and powerful topic for continued work along these lines.

MAJ Douglas B. Bushey, U.S. Army, is chief of the Technology Integration Division at the Missile Defense and Space Technology Center in Huntsville, AL. His work involves integrating innovative technologies into space and missile defense weapon systems. MAJ Bushey holds a M.S. degree in systems management from the Naval Postgraduate School and a B.S. degree in decision science from the Indiana University Business School. (E-mail address: BusheyD@smdc.army.mil)

Dr. Mark E. Nissen is assistant professor of information systems and acquisition management at the Naval Postgraduate School. His research focuses on the application of knowledge systems to change-management problems in areas such as process innovation, electronic commerce, and knowledge management. He has been specializing in knowledge systems to innovate processes in the acquisition domain and is currently engaged in exploratory work on intelligent acquisition agents. Dr. Nissen is also program manager for the External Acquisition Research Program being launched by the Defense Acquisition University, and together with Drs. Keith Snider and David Lamm, he edited the *Acquisition Review Quarterly* special issue, *Managing Radical Change* (1998, Vol. 5, No. 2). Before earning his Ph.D. degree in information systems from the University of Southern California, he acquired more than 12 years' management experience in the aerospace industry and served as a supply officer in the Naval Reserve. (E-mail address: MNissen@monterey.nps.navy.mil)

References

Ashby, W. R. (1956). *An introduction to cybernetics.* New York: John Wiley & Sons.

Augustine, N. R. (1983). *Augustine's laws and major system development programs.* New York: American Institute of Aeronautics and Astronautics Inc.

Beer, S. (1979). *Decision and control: The meaning of operational research and management cybernetics.* New York: John Wiley & Sons.

Department of the Army. (1994, September). *Army focus '94: America's Army in the 21st century.* Washington, DC: Author.

Department of Army. (1993, June 14). *Field manual 100-5, Operations.* Washington, DC: Author.

General Accounting Office. (1995, November 29). *Letter report, battlefield automation: Army's digital plan lacks specific measurable goals* (GAO/NSIAD-96-25). Washington, DC: Author.

Prueher, J. (1996, November 6). *Command strategy.* Remarks from the Commander-in-Chief, U.S. Pacific Command, Superintendent's Guest Lecture Program.

U.S. Army Training and Doctrine Command (TRADOC). (1994, August). *Force XXI operations: A concept for the evolution of full-dimensional operations for the strategic Army of the early 21st century* (TRADOC Pamphlet 525-5). Fort Monroe, VA: Author.

Simon, H. (1977). *The new science of management decisions.* Englewood Cliffs, NJ: Prentice-Hall.

U.S. Army Training and Doctrine Command (TRADOC). (1996, March). *Requirements determination* (Black Book pamphlet). Fort Monroe, VA: Author.

U.S. Army Training and Doctrine Command (TRADOC). (1996, March). *Land combat in the 21st century* (Black Book pamphlet). Fort Monroe, VA: Author.

West, T. D. Jr. (1997, October). *America's Army meets the new millennium* (Army 1997–98 Green Book, pp. 13–16). Washington, DC: U.S. Army.

ENDNOTES

1. In order to simplify the system, we assume all the influences on the enemy are channeled through a single input and all effects are channeled into a single output.

2. A "win" in this example is defined as a clear and decisive victory. All other outcomes result in a loss. The various loss outcomes are represented in Tables 1 and 2 as b, c, and d.

3. Clearly, many factors contributed to success in the Gulf War (e.g., air strikes, tactical skill and savvy of commanders). Indeed, the presence of such a variety of factors strengthens the importance of our distinction between qualitative and quantitative variety.

4. Practically, the framework and analysis can scale to address any number of simultaneous enemy COAs.

5. The EXFOR is a Force XXI-equipped division located at Fort Hood, TX. The EXFOR is the unit that participates in the "digital" National Training Center rotations and other AWEs to test new concepts and equipment.

THE USAF PEO/DAC/MAD STRUCTURE: *SUCCESSFUL PATTERN FOR FUTURE WEAPON SYSTEM ACQUISITION?*

Lt Col Charles W. Pinney, USAF

Among the acquisition streamlining initiatives of the past decade was the creation of the program executive officer position to oversee the execution of a portfolio of related major programs. This officer, in the direct reporting chain between the program manager and the service acquisition executive, has improved and focused program oversight and execution. But the imposed insertion of this position into the existing Air Force acquisition structure has complicated the relative roles and responsibilities with other acquisition officials—specifically, the mission area directors and the designated acquisition commanders—and has had mixed results.

With defense acquisition costs in the 1980s exceeding $115 billion annually and amounting to more than 40 percent of the defense budget (Secretary of Defense, 1993), it was only appropriate that the Department of Defense (DoD) and Congress focus on various acquisition streamlining and reform initiatives. In 1986, the Packard Commission identified numerous shortcomings in the acquisition process and recommended several improvements. These recommendations became the goals of subsequent legislation, Presidential directives and DoD regulations. The result of these actions was a major restructuring of how the Office of the Secretary of Defense (OSD) and the services conduct acquisition activities.

One significant change was the creation of the position of program executive officer (PEO): a corporate operating official who would supervise a portfolio of mission-related major and selected

programs and be accountable to the service acquisition executive (SAE). This line officer, in the direct reporting chain between the program manager (PM) and the SAE, would streamline and focus the activities associated with executing and overseeing these programs. In spite of the many benefits this new position offered, its imposed insertion into an existing organizational structure complicated the relative roles and responsibilities of other acquisition officials, specifically (in the Air Force [AF]) the designated acquisition commanders (DACs) and the mission area directors (MADs).

This research project (carried out for the Industrial College of the Armed Forces), evaluates the Air Force PEO/DAC/MAD acquisition structure in terms of these relationships to assess its contribution to the goals of the Packard Commission. To address this subject, I will first discuss the background of the creation of the PEO position, then focus on the overall Air Force weapon system acquisition structure, with emphasis on the roles and responsibilities of the PEOs, DACs, and MADs. Third, I will discuss the issues that arise in implementing the details of this structure and how they might affect the overall performance of the Air Force acquisition community. Finally, I will present some of the options that may improve the effectiveness of this structure. Because the PEO concept represents the newest addition to a relatively well-established structure, I will present this evaluation primarily from the PEO perspective and use the description of the DAC and MAD roles to frame the discussion.

METHODOLOGY

This research project is the result of a literature search and interviews. Literature sources included official reports, briefings, directives, and memoranda; informal topic and offsite materials; and magazine and newspaper articles. Individuals interviewed included selected present and former members in the PEO/DAC/MAD acquisition structure.

BACKGROUND

PACKARD COMMISSION

In response to public criticisms of sensationalized cost overruns, faulty weapon system performance, and perceived contractor fraud, the Reagan administration appointed David Packard, former Deputy Secretary of Defense, to lead the Blue-Ribbon Commission on Defense Management (commonly referred to as the Packard Commission). This body evaluated defense acquisition, organization, and decision-making, Congressional oversight, and the national command structure Reeves, 1996). Its major task was to determine if the implementation of private sector methodologies could improve defense management business practices (Santo-Donato, 1991, p. 3).

The Commission reported that cost, schedule, and performance problems in weapon system development and procurement were attributable to an encumbered and unproductive acquisition management system. This system lacked, among other things, "(1) clear accountability for acquisition execution and (2) unambiguous lines of authority for individuals with

program management responsibilities" (General Accounting Office (GAO), 1990, p. 1). Another assessment was that the program manager's effectiveness in executing his program suffered from the excessive time and effort spent on preparing reports and briefings (Brooks, 1991, p. 3).

The Commission report made some key recommendations to rectify observed structural and procedural weaknesses in DoD acquisition management. One was that each service should institute a three-tiered structure for all major defense programs. This structure would consist of an SAE,[1] responsible for all acquisition matters; PEOs, individually responsible for a limited group of major programs; and program managers,[2] responsible to the PEO for all program-related matters (GAO, 1990, p. 1). Further, to achieve more efficient and effective management, this acquisition structure should revise its practices and procedures to emulate the characteristics of most successful commercial and government projects. Among these characteristics are:

- clear command channels—clear alignment of responsibility and authority, preserved and promoted through short, unambiguous chains of command to the most senior decision makers;

- program stability—a stable environment of funding and management, predicated on an agreed baseline for cost, schedule, and performance;

- limited reporting requirements—adherence to the principle of "management by exception," and methods of ensuring accountability that focus on deviations from the agreed baseline;

- small, high-quality staffs—reliance on small staffs of specially trained and highly motivated personnel;

- communication with users—sound understanding of user needs achieved early on and reflecting a proper balance among cost, schedule, and performance considerations; and

- better system development—including aggressive use of prototyping and testing to identify and remedy problems well before production, investment in a strong technology base that emphasizes lower cost approaches to building capable weapon systems, greater reliance on commercial products, and increased use of commercial-style competition (Cheney, 1989; U.S. President's Blue Ribbon Commission, 1986; Reeves, 1996).

The Packard Commission submitted its final report in June 1986. President Ronald Reagan implemented its recommendations in National Security Decision Directive (NSDD) 219 (1986).

Legislative Influence

Two contemporary laws also played a role in establishing this new acquisition structure for DoD. First, the Goldwater-Nichols DoD Reorganization Act (Public Law 99-433) (1986) sought "to reduce the bureaucratic layering and duplication existing within the DoD acquisition process, and to produce acquisition programs that would better meet cost, schedule, and performance criteria" (Santo-Donato, 1991). This law designated within OSD the (current) position of Under Secretary of Defense for Acquisition and Technology—USD

(A&T)[3]—while the second law, the National Defense Authorization Act for Fiscal Year 1987 Public Law 99-961), outlined his duties, responsibilities, and authority (Brooks, 1991, p.4).

Unfortunately, this legislation did not achieve the desired change in DoD. Congress and other organizations external to DoD soon began to criticize the Pentagon for failing to complete the acquisition reforms recommended by previous commissions (Willis, 1990). According to the GAO report, these criticisms were based on the Services affixing the new titles to existing positions in the old structures, failing to empower the PM-PEO-SAE chain with the authority and control intended, and failing to eliminate the unnecessary intermediate management layers (GAO, 1990, p. 2).

In response to criticisms, President George Bush directed the Defense Management Review (DMR) in February 1989 to "review DoD management and develop a plan to fully implement the Commission's recommendations, improve the acquisition process, and more effectively manage DoD resources"

DoD Takes Action

In response to criticisms, President George Bush directed the Defense Management Review (DMR) in February 1989 to "review DoD management and develop a plan to fully implement the Commission's recommendations, improve the acquisition process, and more effectively manage DoD resources" (GAO, 1990, p. 2).

By December 1990, the GAO reported that the Services had taken action to revise their acquisition structures to comply with the Commission's intent. What remained was DoD's updating of its implementation guidance, policies, and procedures to reflect the DMR changes.

DoD took the necessary steps in the following months. For example, DoD Directive 5000.1, "Defense Acquisition," DoD Instruction 5000.2, "Defense Acquisition Management, Policies and Procedures,"[4] and DoD Directive 5000.49, "Defense Acquisition Board," all address the role of the Defense Acquisition Executive (DAE), SAE, and PEO (Santo-Donato, 1991, p. 16).

DoD asserted that the implementation would yield improved effectiveness and cost avoidance in weapon system acquisition, with projected savings. Secretary of Defense (SECDEF) Richard B. Cheney stated that these savings would be applied to readiness, modernization, maintaining force structure, and improving quality of life (Fulghum, 1990).

Air Force Implementation of the PEO

In response to the 1986 creation of the PEO position and function, the Air Force originally attempted to use its existing acquisition structure to accommodate the requirements. The Air Force appointed 11 PEOs, most of who were product division or air logistics center commanders. These officers served dual-hatted roles: Keep the Air Force acquisition executive (AFAE) apprised of program status and report to the major commands (MAJCOM) (Air Force Systems Command [AFSC] or Air Force Logistics Command [AFLC]) commander on their control of program resources and major program decisions (Brooks, 1991, p. 4).

The 1989 DMR forced greater changes, however. The Air Force identified six PEOs (five general officers, one senior civilian executive), separate from the product center structures, which would have no other responsibilities. These PEOs oversaw key weapons systems in strategic, information systems, tactical and airlift, space, tactical strike, and command, control, and communications. According to the Secretary of the Air Force (SECAF) Donald Rice, this new system would provide program managers with greater autonomy, responsibility, accountability, and time to focus on their programs. "The PEO would plan corporate strategies and objectives, and serve as a problem-solving team leader supported by the systems and logistics commands." Center commanders would provide support (e.g., needed experts, test and research facilities, and materials) (Schmoll and Cochrane, 1996).

Thus, legislation, regulations, and directives have crafted the structure DoD uses today to develop and procure weapon systems. From this process, the Air Force has delineated an organization for planning, programming, budgeting, and executing acquisition programs. This structure is still viable in the Air Force, but continues to evolve with time as leadership, portfolios, and other needs dictate. Who are the key players in the Air Force acquisition community, and what are their roles and responsibilities?

Structure, Roles, and Responsibilities

Air Force Acquisition Chain of Command

Acquisition Policy Directive 63-1 (August 31, 1993) established the current Air Force acquisition system for "providing new and improved materiel capabilities in response to validated needs and according to public law, appropriate instructions, and international agreements"(Jaquish, 1993). It prescribes the requisite streamlined structure (see Figure 1) in which no more than two levels of review exist between the program manager and the Milestone Decision Authority (MDA). Thus, depending on the dollar value, risk level, and importance of the program, the program manager reports through either the DAC, PEO, or, under special circumstances, directly to the AFAE.[5]

"Thus, legislation, regulations, and directives have crafted the structure DoD uses today to develop and procure weapon systems. From this process, the Air Force has delineated an organization for planning, programming, budgeting, and executing acquisition programs."

This new system effectively took the major command out of the program management chain. HQ Air Force major command focus lies on processes and resource management. The staff is less involved in program management oversight; its role is supporting the acquisition process and providing the funding and human resources the program manager needs to execute his program (Brooks, 1991, p. 17).

The AFAE, who is also the Assistant Secretary of the Air Force (Acquisition) (ASAF[A] or SAF/AQ), is responsible for all Air Force acquisition. His primary responsibilities include "establishing acquisition policy, supervising and evaluating PEOs, actively participating in the

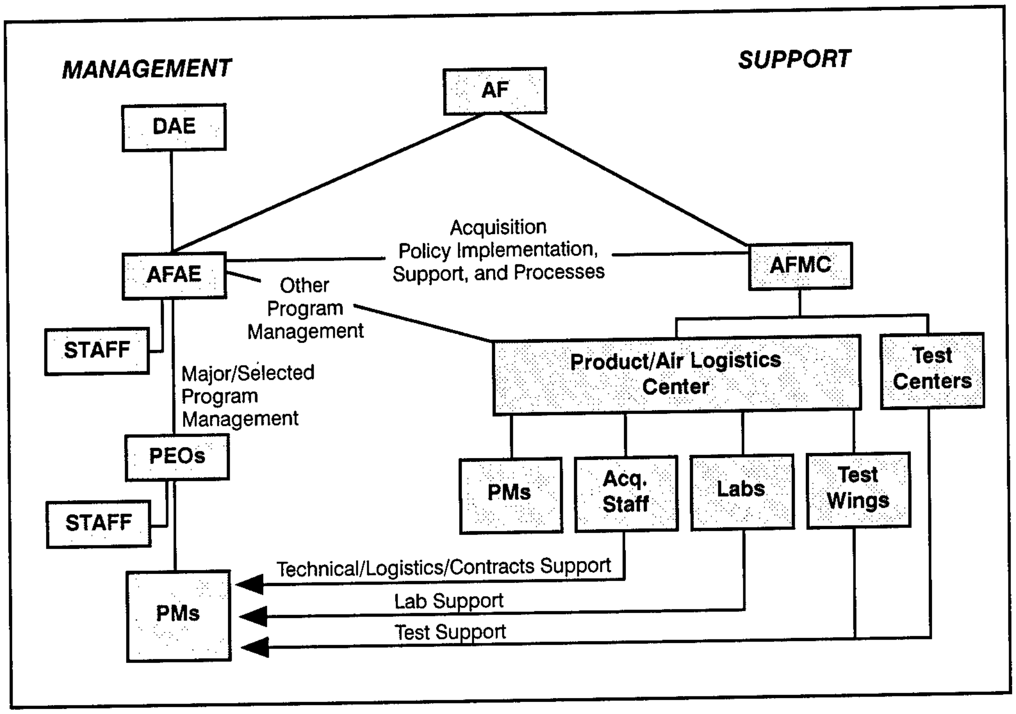


Figure 1. AF Acquisition Structure

biannual planning, programming, and budgeting system (BPPBS) process, representing the Air Force on various acquisition boards, interfacing with Congress and overseeing the execution of all acquisition programs" (Brooks, 1991, pp. 10–11).[6] Figure 2 shows the current SAF/AQ organization.

PEO Structure, Roles, and Responsibilities

In a memorandum forwarding the Air Force progress in meeting DMR goals, the SECAF reiterated that "responsibility and program management authority flows directly from the [AFAE] to the PEOs to program managers [of major and selected acquisition programs]. PEOs will have no other responsibilities and will report to no one on program management outside the SAE/PEO chain" (Rice, 1989). The PEO would be a "senior operating official with the authority, responsibility, and accountability for a portfolio of related programs. The PEO is to be a planner of corporate strategies and objectives, a problem-solving team leader supported by acquisition commands" (Rice, 1989). The PEO is a line officer responsible and accountable to the AFAE for the cost, schedule, and performance (within baseline) of the portfolio.[7]

The PEO exercises authority by: issuing program direction to the program manager,[8] baselining each program using the acquisition program baseline process; and serving as the direct reporting official for the program manager. The PEO exercises accountability through monthly acquisition reports, quarterly

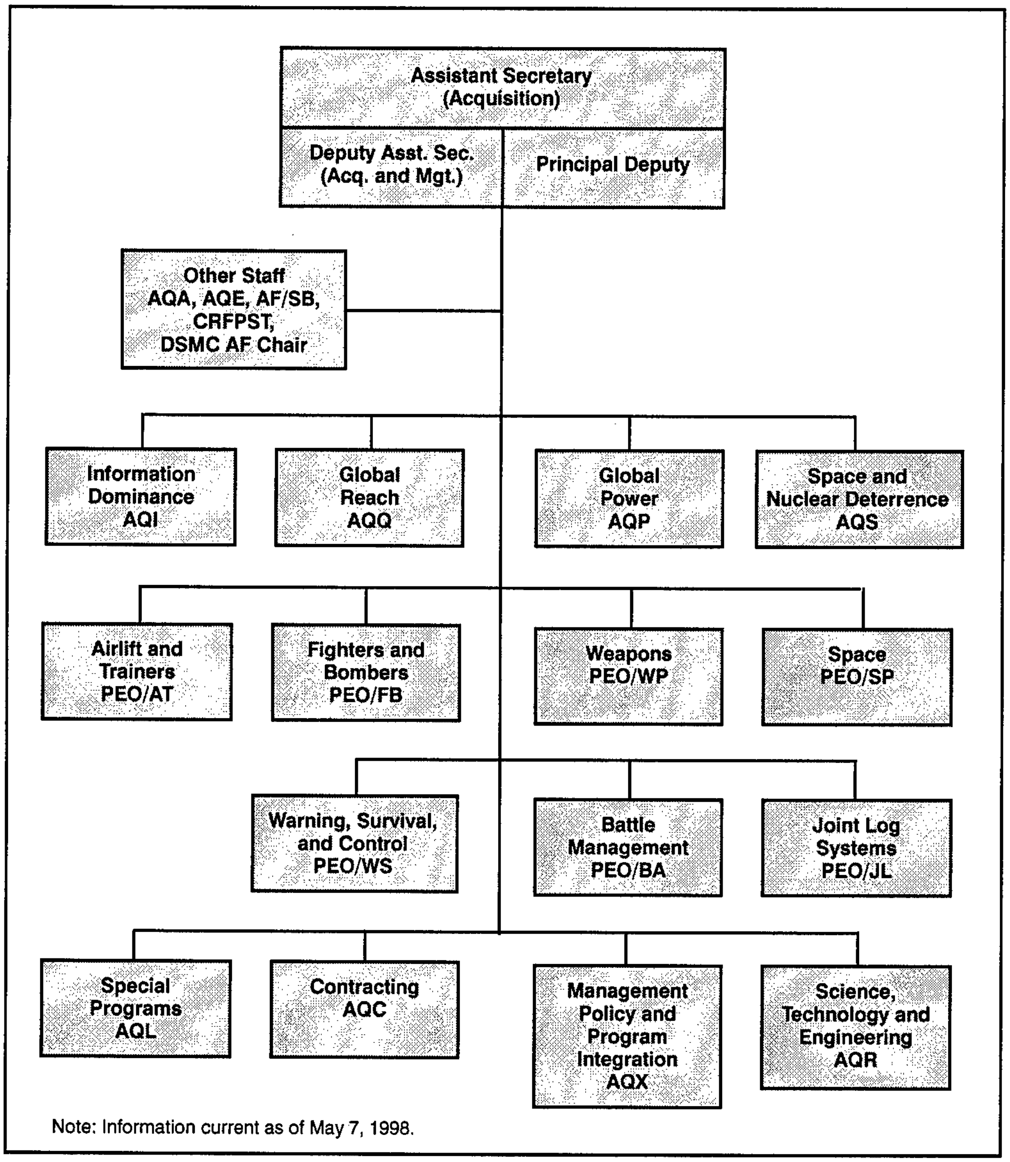


Figure 2. Current SAF/AQ Organization

defense acquisition executive summaries, breach reporting, and direct reporting only to the AFAE (SAF/AQ Management Workshop, 1995).

In implementing the PEO concept, the Air Force identified the following daily responsibilities of the PEO:

- Be deeply involved in all program execution matters.

- Provide program manager wisdom, experience, and insight into Pentagon and Washington politics.

- Screen the program manager from the Pentagon.
- Be the "eyes and ears" of the AFAE—no surprises and make it happen.
- Work with infrastructure managers to ensure support.
- Approve program resource requirements.
- Develop (with the acquisition strategy panel) and implement acquisition strategy.
- Represent portfolio in the major reviews process.
- Counsel with the AFAE and MADs on programming and budgeting issues.
- Validate System Program Office (SPO) prepared program restructures ('what-if' exercises).
- Review all program documentation provided to the Pentagon and the Congress.
- Approve reprogramming of funds within portfolio (in/out) in the execution year.
- Interface with users during program objective memorandum preparation.
- Assist MADs in preparation of Air Force budget.
- Assist MADs in defense of the budget with OSD and the Congress.
- Support MADs on requirements and requirements reviews (summits).
- Evaluate program managers.
- Monitor the "health" of the program management team (Yates, 1990; SAF/AQ Management Workshop, 1995).

However, in spite of the general duties and functions assigned, refining the details of the PEO's role and responsibilities often falls to the individual PEO, his interfaces, and occasionally to corporate vision.

DAC Structure, Roles, and Responsibilities

The same AFAE memorandum that specifies the charter for the PEOs also identifies the responsibilities of the DACs. The product divisions and air logistics centers commanders of Air Force Systems Command and Air Force Logistics Command (forerunners to Air Force Material Command) assume the role of DACs. They perform functions similar to the PEOs. Established in a direct reporting line between subordinate program managers and the AFAE, the DACs are responsible for other than major or selected programs (Welch, 1990). However, as center commanders, the DACs serve an acquisition support role as well.

A SECAF memorandum on October 2, 1989, reaffirmed that "the AFSC and AFLC commanders would continue to be responsible for planning all required support throughout the life of all programs. These commanders [would] recommend, for [AFAE] approval, major program assignments to a PEO and coordinate with

the [AFAE] on other program assignments." They would be directly responsible to the AFAE for support to PEOs and program managers. The quality and availability of support to PEOs and program managers would ensure that SPO staffs "remain as small and efficient as possible" (Rice, 1989).

MAD Structure, Roles, and Responsibilities

The MADs, along with the rest of SAF/AQ acquisition staff, provide the AFAE with the broad expertise and necessary functional support to ensure that his or her "authority, decisions, and management responsibilities are appropriately prepared, supported, and executed" (Welch, 1990). They also facilitate "the continuous interaction and dialogue between the AFAE, the PEOs, and DACs." Further, they function as the "focal point and conduit for all interfaces with Congress, OSD, JCS, other Services, Air Staff, and MAJCOMs" (Welch, 1990).

The MADs "work specific operational, test, technology, and developmental aspects of Air Force acquisition for other than the execution year. They are responsible for their mission area planning, integration, and budget process" (Brooks, 1991, p. 12). They must understand the warfighter's needs in their respective mission areas and ensure that the acquisition process addresses these needs. The MADs authorize programs and outline the responsibilities of the key players through the program management directive. They provide all acquisition inputs to the BPPBS (e.g., program objective memoranda, budget estimate summaries, President's budget) and develop the program budgets within the Air Force Board structure. They also identify reprogramming sources for "top down" directed requirements (SAF/AQ Management Workshop, 1995). Table 1 summarizes the basic responsibilities of the PEOs, DACs, and MADs.

Thus, laws, regulations, and directives have defined the general structure, roles, and responsibilities of the Air Force acquisition chain from the DAE down to the program manager. This collective body has a complex multifaceted challenge to affordably field capable weapon systems to meet the warfighter's needs. The structure that accomplishes this demanding task was not the product of a bottoms-up approach, but rather evolved from a combination of self-generated improvements and imposed modifications. While these identified roles and responsibilities within this organizational structure may appear to be clear and consistent, numerous issues exist in practice. What are these issues and how have they affected the ability of the Air Force to comply with the intent of the Packard Commission? The next sections attempt to answer these questions.

"...laws, regulations, and directives have defined the general structure, roles, and responsibilities of the Air Force acquisition chain from the DAE down to the program manager."

Issues

In spite of the many benefits that acquisition streamlining and reform initiatives have brought to the Air Force acquisition community, they also have introduced some issues related to roles and

Table 1. Comparison of Responsibilities

Responsibility	DAC	PEO	MAD
BPPBS interface			X
Air staff interface			X
Congressional interface			X
Mission area planning and integration			X
Requirements coordination	Shared (DAC programs)	Shared (PEO programs)	Shared
Program management directive	Shared (DAC programs) (coordinates)	Shared (PEO programs) (coordinates)	Shared (issues)
Baselines	Shared (DAC programs)	Shared (PEO programs)	Shared
Defense acquisition executive summary (DAES)	Shared (DAC programs)	Shared (PEO programs)	Shared
OSD interface	Shared (DAC programs)	Shared (PEO programs)	Shared
Preparation for milestone reviews	X	X	
Program planning	X	X	
Program oversight	X	X	
Reprogramming approval in execution year	X	X	
Program execution	X	X	
SPO resources requirements generation	X (DAC programs)	X (PEO programs)	
SPO resources support (personnel, facilities, etc.)	X[1]		
Rating of PEO program office personnel	X (except PM)[2]	X (PM only)	

[1] As the product center or air logistics center commander.
[2] Information is current as of May 7, 1998.

responsibilities within the PEO/DAC/MAD organizational structure. Many of these issues arise from the introduction of the PEO into the community and his role relative to the program manager, AFAE, DAC, and MAD. The PEO's role is unclear because it's relatively new, it naturally overlaps the roles of others in an already complex operating environment, and no formal process exists to resolve legitimate differences between the PEO and the others. Other issues deal with the "dual-hatted" nature of many key players, which leads to having two bosses or two sets of

assigned responsibilities. The first few issues deal with defining the role of the PEO.

PEO: Super Program Manager or Junior AFAE?

The lack of clarity of the PEO's role has led some observers to ask where the PEO's primary function resides in the direct reporting chain. Is the PEO a "super program manager," wrapped in the details of managing and executing the programs in his portfolio? Or is the PEO a "junior AFAE," providing wisdom and "top cover" for the program manager, yet lacking the authority to make milestone decisions? As one PEO (and former program manager) interpreted this relationship: "The PEO is the former only when the program manager asks for help or a train wreck is impending. It's like UPT [undergraduate pilot training]: take control too soon and the student doesn't learn; too late and he doesn't survive. The proper position is closer to the latter. The PEO bridges the gap between the program manager and the AFAE. The PEO belongs in the Pentagon so that he doesn't screw with a program too much."[9]

So, the PEO must provide acquisition expertise when the program manager needs it. The PEO must understand and work the politics inside the Beltway and within the Pentagon and advise the program manager on the sensitivities and realities. The PEO's forward presence enables him to defend the program while screening the program manager from many of the "brush fires" and time-consuming diversions of the Washington environment.

The PEO also must be aware of the programmatics and challenges of the programs in his portfolio, and ask: What does the program manager need? The PEO is in a unique position to aid his program managers. As a PEO summed up the situation, "The PEO appears to be the only person with a small enough span of control to help the program manager. The PEO can get on the phone with enough horsepower and contacts to get work done. The center commanders are swamped running their centers and the MADs don't know all of the details."

"In reality, then, the PEO is both a super program manager *and* a junior AFAE."

In reality, then, the PEO is both a super program manager *and* a junior AFAE. He aids each end of the Air Force acquisition chain of command to ensure information, policy and guidance, and decisions flow freely and accurately in both directions.

Dilution of the PEO's Role

The PEO charter specified that the "PEO organization is a field agency reporting directly to the AFAE and not part of the Assistant Secretary's acquisition staff" (Welch, 1990). According to one PEO, however, that relationship is often lost on current senior officials.

> Mr. Welch [AFAE] and General Jaquish [his principal deputy] had a clear view in the beginning. They did not have the PEOs attend AQ staff meetings, but rather held separate meetings with the PEO to discuss program execution. PEOs did not coordinate on or sign staff summary sheets, because they didn't do staff work. That was part of the

> reason for the small staff size. Since then, there has been a blurring of roles; much of the PEO work is not known or understood by newcomers. The early implementation dealt with what should be the structure, how to put it together, and what should be the charter to meet the Packard Commission intent. With the turnover of personnel, the new folks haven't gone back to review the charter, and don't know the responsibilities. PEOs now have demands that compete with their primary roles: membership on process action teams, policy coordination, etc.

The option of establishing a Deputy PEO (O–6 or GM–15) position can help mitigate the increased workload, but a problem still exists in the basic understanding of the PEO's position and function. Even the SAF/AQ organizational chart (Figure 2) can be confusing. Again, a PEO reminds the listener:

> PEOs are not on the AQ staff, but rather represent field operating agencies and carry Air Force Program Executive Office SEIs [special experience identifiers]. This fact is lost on a lot of people. The MADs come in from Using commands and just see the areas closely aligned with their responsibility; they don't see the activities unique to the PEO: contracting approval (business clearance), acquisition strategy panels, justification and approvals, acquisition plans, source selection authority, undefinitized contract actions, and [the execution] budget.

Clearly, a misunderstanding of the PEO's position has been a recurring theme since its creation. Much of the confusion lies in the overlapping nature of the roles and responsibilities of the PEO and those of the DAC (as the center commander) and MAD.

Overlapping Responsibilities (PEO/DAC (Center Commander))

The DAC's role as a center commander establishes a closely linked relationship with the PEO that has had mixed results on execution. The product or air logistics center commander is responsible for policies, procedures, facilities, staff support, personnel, and training. These elements are essential for supporting the PEO program. They avoid redundancy and enable a small PEO staff. However, the operating relationships can overlap and become unclear.

The central issue is the point at which support ends and program control begins. Even in a support role, the center commander influences program execution and effectiveness. The people and facilities he or she provides, the policies imposed, and the training requirements levied all influence the quality of the inputs to the acquisition process and, therefore, affect the product. One PEO expressed his concern: "Separation of resource control and program execution responsibility is unnatural in our culture, and we do not have a complete understanding of the interfaces." This issue has several dimensions.

First, the center commander provides the people that serve on the programs in

accordance with his charter. However, PEOs often express concern that their ability to influence this decision has been limited. A DAC once expressed to his staff: "The PEO tells me what positions he needs filled on one of his programs, and I determine who will fill them." The center commander, in essence, determines the relative priority of this program when it comes to providing support. Usually, this concern is not a significant problem. However, one PEO related that he had lost a senior member of one of his programs (an O–6) to another program without the commander notifying him of the reassignment.

Second, except for the program manager (system program director, or SPD), the center commander has the responsibility for evaluating all program office personnel. Thus, functional experts who fill matrix positions within a PEO program face the potential dilemma of divided loyalties.

Third, the center commander controls the budget for many resources: contractor support, program manager salaries, travel and office operations, system-specific software engineering and new equipment training. Sometimes the PEO lacks the sufficient visibility and control into this portion of the budget that directly affects the program baseline.

Fourth, in reviewing the status of functional support to PEO programs, the center commander is in a position to influence program execution. Certainly a functional review is appropriate, but problems arise if this meeting broadens into a program review where direction replaces advice and insight.

Finally, the center commander is in a position to task program personnel in a manner that detracts from their contribution to the program. As one PEO pointed out, "When the center's contracting officer reviews a document for my program, he's working for me, not the center commander. It's okay to pass the information on to the commander, but not okay to impose extra work on the program [e.g., to provide the data in the center's preferred format]." He went on to cite other conflicts with his program's needs, such as the commander having the program manager attend an offsite with him on center matters or tasking a program O–6 to run an air show. According to a former deputy program director on a major program, "Roughly 30 percent of the time I spent on the program involved handling the support from the DAC."

"Even in a support role, the center commander influences program execution and effectiveness."

These factors in the overlapping relationship between the PEO and the DAC can confuse the program manager and his SPO personnel. To whom do they go to first on matters of advice and counsel? Sometimes the answer is as much a matter of proximity (collocation with the center's functional support) and rank ("How do you say 'no' to a three-star?") as it is the acquisition chain of command. In fact, said a PEO, "Program personnel have occasionally played the center commander and PEO off each other—depending on which position or chain of command better serves their purpose."

These potential problem areas stem from the chartered relationship in the PEO/DAC/MAD acquisition structure. Fortunately, they usually are neither frequent

nor serious in nature. The PEO and the DAC (center commander) both have responsibilities and faithfully seek to accomplish them all. Where ever they conflict, negotiating a mutually acceptable solution is the best course. A PEO reinforced this consideration, "Having a good rapport with my counterparts prevents adverse effects; the relationship makes it work."

OVERLAPPING RESPONSIBILITIES (PEO/MAD)

The PEO and MAD also experience a complex relationship that proves both beneficial and difficult. Although they have different job descriptions, their areas of responsibility dovetail at best and conflict at worst. The PEO focuses "downward" toward the SPOs, contractors, and industry, and the warfighters related to the programs in his portfolio. The MAD perspective takes an external view, dealing with the Air Staff and Secretariat, the other Services, OSD, Congress, the media, and the warfighters related to his mission area. The PEO deals with the execution of his programs with current year funds. The MAD plans, programs, and budgets for future year efforts.

"The magnitude of effort to usher a weapon system through the BPPBS and acquisition milestone processes is far beyond what one individual and his staff can accomplish."

These different perspectives can be beneficial. Different views and goals provide a creative tension. The magnitude of effort to usher a weapon system through the BPPBS and acquisition milestone processes is far beyond what one individual and his staff can accomplish. However, acting as a team, the PEO and MAD can complement each other's role to jointly succeed in their tasks. For example, the MAD's interaction with Congress, the rest of DoD, and other outside agents clear the PEOs to concentrate on program execution. In return, the PEO's detailed program insight can facilitate the MAD's disseminating information, coordinating requirements, and generating BPPBS inputs and reclamas.

Still, the overlap in the activities of these two offices can place a strain on the acquisition process. Sometimes the strain is structural in nature. The PEO has responsibility for current year execution, but the MAD takes the lead for out-year budgets. Clearly, funding cuts to the latter affects the conduct of the former. Hence, the PEO is accountable for sound program execution, but has little control over the process of resourcing future needs. At other times, the strain is a matter of experience and perspective. Take, for example, the experience of a former Acting SPD (program manager) of a major joint program. "A Congressional staffer sought to reduce our program office manning by 50 percent. Our PEO assembled a rebuttal to fight it, but the MAD didn't think it mattered and failed to forward it to the staffer. It took significant effort to recover most of this cut."

The program manager, too, feels this strain in needing to work with both the PEO and the MAD on issues where the lead responsibility is unclear. For example, when Congress asks questions on program details (e.g., "What are you doing with the management reserve?" "Why aren't you on contract?"), should the MAD answer the question because he is the Congressional interface? Or should the PEO

answer it because he has extensive insight into the program? Other examples of this gray area are "what-if" drills from OSD, other agency inquiries, foreign military sales,[10] and taskings from outside the directed programs.[11]

PEO and MAD activities will continue to overlap. Said one PEO, "It's possible to do some of each other's stuff (I wordsmith all answers to Congress), but each should always invite the other to review and coordinate. Interpersonal relations determines how it will work out."

Recently, SAF/AQ (AFAE) restructured the MAD and PEO portfolios to better align and ease coordination and communication. Yet perfect one-on-one alignment is unlikely between program portfolios and mission areas. Added one PEO, "The emergence of information systems nearly guarantees more than one MAD with which to interface. For example, weapon systems using information systems in development will require the overseeing PEO to deal with the MAD for information dominance as well as the director overseeing the mission area containing the weapon system."

In reality, one cannot do his job without the other. Coordination, teamwork, trust, and mutual support are essential to accomplishing their collective tasks. These attributes compensate for the lack of clarity between in the role of the PEO and those of the other members of the acquisition community. However, not all of the issues stem from the establishment of the PEO. Some issues result from the "dual-hatted" nature of the several key players within the community.

"Dual-Hatting" of Acquisition Leadership

The "dual-hatting" of the program manager, DAC, and AFAE often imposes difficulty in the acquisition process. These individuals have to respond to multiple "bosses" or have to perform more than one set of responsibilities. As shown earlier, the program manager has to deal effectively with the PEO/DAC and PEO/MAD overlaps. In the first case, the program manager of a major program must work with the DAC (as a center commander) for his resources and acquisition support and with the PEO for execution matters. In responding to Congressional inquiries and OSD taskings, he must deal with both the MAD and the PEO. Again, this duality can generate confusion and redundant taskings.

The DAC, too, performs dual roles and serves more than one boss. In fulfilling his DAC roles, he responds to the AFAE on all acquisition matters concerning his portfolio. On resources and acquisition support and for sustainment matters, he responds through the Air Force Materiel Command (AFMC) commander to the Air Force Chief of Staff. Two concerns arise from this situation. First, like the program manager, the DAC has a complex task in satisfying two different superiors whose diverse interests potentially overlap and may conflict. Second, the 1989 shift in the acquisition chain of command away from the AFSC (now integral to AFMC)

> **"The "dual-hatting" of the program manager, DAC, and AFAE often imposes difficulty in the acquisition process."**

commander to the AFAE effectively splits acquisition from sustainment. One of the purposes in combining AFSC and AFLC into AFMC was to instill a "cradle-to-grave" perspective in integrated weapon system management. While the execution-level organization may embrace this perspective, it is not a natural byproduct of at the senior Air Force command structure.

Finally, the AFAE also wears two hats and serves two bosses. For example, as SAF/AQ, Mr. Money reported to SECAF Widnall on Air Force acquisition matters. However, as the AFAE, Mr. Money reported to the DAE, Dr. Kaminski, who was the MDA for Acquisition Category (ACAT) I D programs.

These dual-hatted positions are not necessarily counterproductive—they may be the best use of acquisition expertise and a logical fusion of roles to ensure a consistent policy, program execution, and reporting. Nevertheless, coordination and interaction with these dual-hatted positions can be complex and require special attention to the relationships.

"These dual-hatted positions are not necessarily counter-productive—they may be the best use of acquisition expertise and a logical fusion of roles to ensure a consistent policy, program execution, and reporting."

Thus, the Air Force acquisition structure has problems in role definition, responsibility overlap, and dual-hatted leaders. How do these issues affect the benefits sought from implementing the Packard Commission recommendations?

Meeting the Packard Commission Intent

The Packard Commission cited the lack of accountability and unambiguous authority in acquisition programs and the burdening of the program manager with non-value-added reporting requirements. The Air Force implementation of the recommended three-tiered (AFAE-PEO-PM) structure for major defense programs meets the Commission's intent and largely corrects the identified shortcomings. However, as the previous section points out, this structure falls short of total compliance. Consider this assessment in terms of the desired characteristics of successful projects: clear command channels, program stability, limited reporting requirements, small, high-quality staffs, communication with users, and better system development.[12]

Clear Command Channels

The evolution of the Air Force acquisition structure, a direct result of implementing the Packard Commission recommendations, specifically addresses the desire for clear command channels. DoD policy instituted the AFAE-PEO-PM and AFAE-DAC-PM direct reporting chains for all acquisition programs, establishing accountability and reducing bureaucracy. The AFAE position as the single civilian responsible for all Air Force acquisition matters strongly benefits this goal. Program managers have a defined and direct reporting path through at most one individual (a PEO or DAC) to the AFAE. Further, PEOs and DACs have "privileged lines of communication to the AFAE" (Welch, 1990). This streamlined reporting

structure can be particularly useful for situations dictating timely acquisition communication and decision making. According to one PEO, "Streamlining has occurred. Now when a breach occurs, the reporting and working of the issue is much faster. [The chain is no longer] 'PM-center commander-AFMC/Commander-Chief of Staff of the Air Force (CSAF)-SECAF,' but rather 'PM-PEO-AFAE.'"

While program execution benefits from this three-tiered reporting structure, the command channel is less clear in matters of support and planning. Previous discussions illustrated how overlapping roles and responsibilities and the dual-hatting of key positions introduce complex interactions that confuse both participants and observers alike. SPO personnel must keep both the PEO and the center commander (DAC) satisfied. Also, they must respond to both PEO and MAD taskings, balancing and integrating the information to meet overlapping needs. Further, the DAC and the AFAE have other demanding duties they perform to satisfy superiors outside the direct reporting chain for acquisition matters. Again, cooperation and coordination compensate for these structural imperfections. However, compensation is less likely for those individuals who interact with the acquisition community from the outside.

MAJCOM commanders, for example, often fail to appreciate the various nuances. As one PEO pointed out, "The four-stars don't like the system. It's due to denial, ignorance, and the desire to talk to another four-star vice a one-star. They take up their issues with the AFMC commander and the product center commander, who have no authority on the [PEO] programs. Instead, they need to talk to the AFAE and the PEO." Even then, confusion may persist: On one occasion where the MAJCOM commander forwarded an issue to a PEO, it involved a weapon system already transferred out of the acquisition realm and into the CSAF-AFMC-system support manager sustainment chain.

Thus, the acquisition chain offers a streamlined command chain with clear accountability in execution. However, structural conflicts and overlaps in responsibilities complicate the handling of several important matters germane to the execution process and the principles of integrated weapon system management.

Program Stability

The impact of this acquisition structure on program stability is similar to its affect on the command chain. The focusing of acquisition activities around the three-tiered acquisition structure facilitates a coherent policy and acquisition strategy. A PEO, with responsibilities restricted to the execution of his portfolio of related programs, aids program stability by bridging the interests and needs of the program manager and the AFAE. His attentive oversight extends the AFAE's effectiveness. His focused protection of the program manager's program from outside influences helps shelter the program from destabilizing funding cuts and non-value-added taskings. His ability to move money around within his portfolio

"The focusing of acquisition activities around the three-tiered acquisition structure facilitates a coherent policy and acquisition strategy."

further adds to program stability. Barring a dilution of his role with additional staff duties, the PEO is a stabilizing influence on his portfolio's programs.

Again, however, overlapping responsibilities and dual-hatting can have detrimental effects on program stability. For example, while the PEO can control current year execution and responses to funding cuts, the MAD has the future year programming and budgeting responsibilities. A concerted effort of both the MAD and the PEO is necessary to ensure program stability.

Limited Reporting Requirements

Establishing a three-tiered acquisition structure directly reduces the number of levels required to gain approval for program milestones. Certainly the PEO's role and location in the Pentagon relieve the program manager from encumbering briefing demands. Also, by handling a portfolio of related programs, the PEO and the DAC filter the detail and quantity of briefings and reports the AFAE has to receive.

But while the approval briefing requirements are fewer, the program manager has increased demands of coordination and information reporting to address his interface with the center commander and the MAD.

Small High-Quality Staffs

The Air Force implementation of the PEO position limited the staff size to six people. Initial arguments suggested that a staff more than three times that large would be necessary to properly oversee an entire portfolio of programs. However, the prevailing attitude of senior acquisition officials was that the 2000 personnel located in the SPOs represented the expertise necessary to execute the programs. The PEO and his staff needed to tap that existing capability rather than adding redundancy to it. Still, over time some PEO staffs did expand to include the position of a deputy PEO. This individual helps shoulder the PEO's demanding portfolio (often spread across three product centers) and Pentagon responsibilities.

Communication with Users

All members of the acquisition chain have a responsibility to communicate with the warfighters as part of their collective charters. At the intermediate level, the PEO shares this responsibility with the appropriate MAD(s). Their perspectives are slightly different, but taken together and properly coordinated, they should be able to address the user's needs. Again, though, some users have been unclear with whom (e.g., PEO or MAD, AFAE or AFMC/CC) they should deal on certain issues.

Better System Development

The new acquisition structure does not specifically address system development improvements. Many other acquisition reform initiatives focus on this characteristic. Still, a command chain that operates with a coherent policy and strategy and uses efficient reporting mechanisms is better equipped to develop affordable and effective weapon systems.

In general, then, the Air Force acquisition structure meets the intent of the Packard Commission. It reduces bureaucracy and provides a streamlined command chain accountable for program execution and reporting. The tiered nature of the AFAE-PEO-PM chain allows each

level to focus on key needs and capabilities that enhance program stability and enable better system development. The MADs and center commanders (DACs) play vital roles in this complex process. However, their support also complicates the lines of authority, control, and responsibilities. Much of the difficulty is unavoidable and usually does not create substantial problems. Still, senior leadership continues to seek solutions to refine the overall process. What are some of the current options under consideration?

Options for Improvement

As the PEO/DAC/MAD acquisition structure evolves, the participants have proposed numerous alternative implementation approaches to improve both process and product. One improvement recently incorporated by some PEOs was the addition of the deputy PEO position to assist in the oversight role, both in Washington and in the field. Another involved the restructuring of portfolios to better align the PEO and MAD areas of responsibility. Many suggestions have fallen by the wayside, victims of an impracticable, unwanted, or unbalanced implementation plan.

However, two recent ideas proposed at the SAF/AQ Workshop in June 1995 warrant discussion. The first involves drawing the PEO and MAD activities into a tighter relationship to improve coordination and cooperation. The second involves dividing the DAC and center commander duties among two senior officials. These proposed changes directly address two important weak points in the Air Force acquisition structure: the overlap in responsibilities between the PEO and the MAD, and the dual-hatted role of the DAC.

Collocate or Combine MAD and PEO Staffs

One approach to reducing the difficulties experienced due to the PEO/MAD overlap in responsibilities is to collocate or combine their staffs. Collocation helps to build trust and cooperation. This arrangement improves efficiency through shared expertise and improved coordination. It also facilitates a common, balanced focus on BPPBS inputs, program execution, and interaction with all interfaces, within and outside the acquisition community. SAF/AQ recently intended to collocate the PEO and MAD staffs, but a scheduled move out of the Pentagon (during its refurbishment) interrupted the plan. Combining staffs extends the collocation concept further and also permits a reduction in manning.

> **"Collocation helps to build trust and cooperation. This arrangement improves efficiency through shared expertise and improved coordination."**

Unfortunately, these initiatives have drawbacks as well. The current structure provides a "creative tension" that two different perspectives bring. Areas of concern to both parties undergo a system of checks and balances. One PEO expressed a concern of the PEO role becoming subordinate to that of the MAD. Combining the staffs would make dual leadership cumbersome and potentially counterproductive. Another difficulty lies in the proper handling of all matters the

PEO and MAD currently address; combining these activities creates an unwieldy span of control. Finally, because the PEO portfolios and the MAD areas of responsibility do not perfectly align, some discontinuities would remain across the acquisition front between the two sets of responsibilities.

Still, the collocation or near collocation of staffs has merit. The benefits of improved efficiency and interaction between the PEO and the MAD reduce the problems generated by their overlap in responsibilities. Careful attention to the drawbacks can mitigate their impact.

PRODUCT CENTER REALIGNMENT—DEPUTY COMMANDER AS "FIELD PEO"

Another proposal from the SAF/AQ Workshop entailed separating the DAC and center commander duties. Center commanders would continue handling personnel, processes, training, and support. The deputy commander would assume the DAC duties and become essentially a "Field PEO." His responsibilities would be the same as the current PEOs, except he would operate at the product center and oversee a portfolio of "other than major or selected" programs. Because of the acquisition category of the programs involved, posting this individual at the Pentagon would not be necessary. This restructuring would eliminate the dual-hatted problem of running a product center and serving as the DAC.

"Careful attention to the drawbacks [of staff collocation] can mitigate their impact."

While this proposal reduces the span of control of a critical acquisition and leadership position, it still does not address the PEO/center commander overlap in responsibilities in resourcing and executing a program. Instead, it adds a second overlap between the field PEO (DAC) and the center commander. Two individuals would need to address issues formerly resolved by a single individual—and one of these individuals would be directly reporting to the other.

The field PEO concept makes sense. However, to properly realize its benefits, the field PEO should report to the AFAE and not the center commander. This implementation would not solve the overlap issue, but it better serves program execution and accountability.

CONCLUSIONS AND RECOMMENDATIONS

The close scrutiny given to the acquisition process over the past decade identified a need for streamlining and reform. One initiative created the PEO and "inserted" this position into a three-tiered direct reporting chain. The PEO's duties focus on overseeing the execution of a portfolio of related programs. He provides the program manager top cover, helps the AFAE with his span of control, and bridges the linkage between the two.

Inserting the PEO position modified an existing structure. The implementation did not result from a bottoms-up construction. Consequently, incongruities developed. The roles and responsibilities of the PEO overlapped those of the DACs/center commanders and the MADs. Blurred roles, conflicting responsibilities, and dual-hatted leadership have occasionally undermined the program execution and support process. Often, the program

manager and the SPO find themselves caught between two worthwhile but conflicting demands.

Yet the process can and has worked. Personality, trust, coordination, and cooperation can foster the relationships and efficiency to overcome these hurdles. The fact that many of the key players in the PEO/DAC/MAD/PM structure have filled more than one of these positions promotes a bond of understanding. Unfortunately, the turnover of key participants requires continuous adjustment and re-education along the learning curve to make the system work.

The process continues to evolve. Room for improvement still exists. The genesis of this improvement lies in continued discussions (e.g., offsites) that bring issues to forefront where they can be aired and resolved. These discussions generate options. Some options, though plausible, fall short for a variety of reasons (e.g., current structure, inertia, different perspectives, different functional responsibilities, and impractical span of control).

Other options, though, stand out as reasonable improvements worthy of implementation. In particular, I recommend that senior Air Force leadership give further consideration to the following two modifications to currently proposed changes.

First, at the earliest opportunity, collocate (or nearly collocate) the PEO and MAD staffs to increase the positive aspects of close interaction and to resolve issues due to overlaps in responsibility. Do not combine these staffs, but rather retain their independence. Their spans of control are manageable and their different perspectives promote a creative tension that can ensure an optimized and balanced solution.

Second, create a field PEO position that assumes the current DAC responsibilities. This individual would report directly to the AFAE for his portfolio of programs. Like the current PEOs, field PEOs would have a small staff and receive acquisition support from the center commander. The PEO/center commander overlap in responsibilities would remain an area of concern requiring cooperation and further attention.

These recommendations seek to enhance an acquisition structure that currently handles the difficult and complex acquisition process in spite of its structural flaws. Further clarification of roles and responsibilities is appropriate. The interfaces and overlaps between positions should yield synergy, not duplicity or conflict. Continued refinement to the Air Force acquisition structure will ensure a successful pattern for future weapon systems acquisition.

Lt Col Charles W. Pinney is the deputy program director for the Airborne Laser. He's a graduate of the U.S. Air Force Test Pilot School and holds master's degrees in aeronautics, electrical engineering, business administration, and national resources strategy. He is a graduate of the Defense Systems Management College PMC 90-1 and EPMC 98-3 courses and is a Defense Acquisition Corps member certified at Level III in program management, test and evaluation, and systems planning, research, development, and engineering.

(E-mail address: PinneyC@plk.af.mil)

ENDNOTES

1. Synonymous terms for the service acquisition executive (SAE) are the component acquisition executive (CAE) and, for the Air Force, the Air Force acquisition executive (AFAE).

2. Synonymous terms for the program manager include, in some cases (i.e., for major programs), program director (PD), or system program director (SPD). The term single manager, which can represent a SPD, product group manager, or materiel group manager, may also substitute for program manager in certain (usually acquisition) cases.

3. Originally designated as USD(A), this individual also serves as the defense acquisition executive (DAE).

4. DoD Instruction 5000.2. Assignment of Program Executive Responsibility—Description: "Each component acquisition executive should appoint a number of program executive officers (PEOs) who, like group general managers in industry, should be responsible for a reasonable and defined number of acquisition programs. Program managers for these programs should be responsible directly to their respective PEO and, on program matters, report only to him. In other words, every major program should be set up as a center of excellence and managed with modern techniques."

5. AF Policy Directive 63-1:

   Para. 1.4.3.1. Air Force ACAT I D programs are managed by the AFAE, a program executive officer (PEO), and an SPD, with the defense acquisition executive as the MDA. The AFAE is the MDA for ACAT I C programs. Occasionally, an ACAT I program may not be assigned to a PEO, and the SPD will report directly to the AFAE. Air Force ACAT I C programs that meet the conditions specified in Department of Defense (DoD) Instruction 5000.2, Defense Acquisition Management Policies and Procedures, February 23, 1991, may be transferred to a designated acquisition commander (DAC).

   Para. 1.4.3.2. Major Automated Information Systems programs (ACAT I M) are managed by the AFAE, a PEO, and an SPD with the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) as the MDA.

   Para. 1.4.3.3. Air Force ACAT II programs are managed by the AFAE, the DAC, and an SPD, unless the program has been selected by the AFAE for special oversight and assigned to a PEO. The AFAE is the MDA for ACAT II programs.

   Para. 1.4.3.4. Air Force ACAT III and IV programs are managed by the AFAE, the DAC, and an SPD, unless the program has been selected by the

AFAE for special oversight and assigned to a PEO. The AFAE will exercise his or her responsibilities on an exception basis when considered necessary as a result of a report from the DAC. The DAC is the MDA for ACAT III and IV programs. DACs may recommend to the AFAE that smaller dollar value, low-risk programs be designated as ACAT IV. The MDA for these ACAT IV programs may then be delegated below the DAC by the AFAE.

6. AF Policy Directive 63-1, para. 1.6.1.... Unless otherwise directed by SAF, the AFAE is the MDA for ACAT I C through IV programs and may delegate this authority as appropriate. With the exception of selected programs, the AFAE has delegated MDA for ACAT III and IV programs to the appropriate DAC. The ASAF(A) is the AFAE, the senior procurement executive, and the senior information resource management official.

7. Both PEO and DAC portfolio contents are available on the Internet at the SAF/AQ Web site, www.safaq.af.mil.

8. Consistent with the responsibilities outlined in the Program Management Directive, as authorized by the applicable MAD.

9. The National Defense University academic nonattribution policy precludes identifying the specific source of the cited material unless it has been released previously. Subsequent unattributed quotes in this article reflect this policy.

10. Foreign military sales also involve SAF/IA.

11. Examples include PEO/MAD overlap in responding to imposed environmental mandates and data collection requests on areas such as composites development.

12. Remember, however, that this assessment relates only to the impact of the new acquisition structure, and not the contribution of other acquisition reform initiatives, on the six desired characteristics.

REFERENCES

Brooks, T. A. (1991). *The Air Force program executive officer structure* (Executive Research Project, Industrial College of the Armed Forces). Washington, DC: National Defense University.

Cheney, D. (1989, July). *Defense management report to the President* (p. 8). Washington, DC: U.S. Government Printing Office. Other implemented recommendations include: "Creating of an Under Secretary of Defense for Acquisition, recodifying federal law into a single, consistent, simplified procurement statute; and expanding use of commercial products by eliminating military specifications and 'those features of current law and regulation that are at variance' with expanded acquisition of commercial products."

Fulghum, D. (1990, January 22). Program executive officers are among acquisition reforms. *Air Force Times, 50* (24), 3, 16.

General Accounting Office (GAO) report to The Honorable William V. Roth, Jr., U.S. Senate. (1990, December 5). Washington, DC: U.S. General Accounting Office.

Goldwater-Nichols DoD Reorganization Act, Pub. L. No. 99-433 (October 1986).

Jaquish, J. E. (1993, August 31). AF Policy Directive 63-1, "Acquisition System" (p. 1). Washington, DC: SAF/AQ.

National Defense Authorization Act for Fiscal Year 1987, Pub. L. No. 99-661.

National Security Decision Directive 219, Implementation of the Recommendations of the President's Commission on Defense (1986, April 1).

Reeves, S. V. (1996). *The ghosts of acquisition reform: Past, present and future* (1996 Executive Research Project, The Industrial College of the Armed Forces). Washington, DC: National Defense University.

Rice, D. (1989, October 2). *Air Force defense management review report, memorandum for the Secretary of Defense and Deputy Secretary of Defense* (p. 4). Washington, DC: U.S. Government Printing Office.

SAF/AQ Management Workshop. (1995, June 25–27). Aspen Institute, Queenstown, MD (group discussion).

Santo-Donato, A. S. (1991, April 5). *Program executive officer (PEO) Concept: Is it functioning as intended?* Carlisle, PA: U.S. Army War College.

Schmoll, J. H., & Cochrane, C. B. (1996, June). *Introduction to defense acquisition management* (3rd ed.) (p. 25). Ft. Belvoir, VA: Ft. Belvoir Press (Defense Systems Management College).

Secretary of Defense. (1993, January). *Report of the Secretary of Defense to the President and the Congress* (p. 143).Washington, DC: U.S. Government Printing Office.

U.S. President's Blue Ribbon Commission on Defense Management. (1986). *A quest for excellence: Final report to the President* (p. 51). Washington, DC: Author.

Welch, J. J. Jr. (1990, November 12). *Charter for Air Force acquisition program executive officers and designated acquisition commanders, memorandum for distribution.* Washington, DC: Department of the Air Force.

Willis, G. (1990, January 22). DMR may spur huge DoD shift. *Air Force Times, 50* (24), 16.

Yates, R. (1990, February 9). *PEO implementation briefing* (pp. 12–13). Washington, DC: Department of the Air Force.

BIBLIOGRAPHY

Ginovsky, J. (1990, January 22). New Air Force cuts, command overhauls outlined. *Air Force Times, 50* (24), 3, 16.

Vazquez, B., & Lockhart, G. (1994, July-August). Ten sure-fire ways to create Pentagon problems: A humorous look at maintaining a good PEO staff-PEM relationship. *Program Manager, 23* (4), 33–35.

OPEN SYSTEMS AND THE SYSTEMS ENGINEERING PROCESS

Michael Hanratty, Robert H. Lightsey, and Arvid G. Larson

The point of open systems acquisitions is to ensure that we obtain the most effective weapon systems possible—systems that are affordable, accommodate changing technology, and promote multiple sources of supply. Establishing a disciplined systems engineering approach is essential to achieving this goal.

The open system approach is both a technical approach to systems engineering and a preferred business strategy that is becoming widely applied by commercial manufacturers of large complex systems. It has the attention of Department of Defense (DoD) managers, who have mandated its use by DoD systems developers. Why? Because without such a change in system development practice, DoD risks being unable to afford to maintain continued superior combat capability.

Today, legacy weapons systems continue to be developed with their own often-unique and frequently closed infrastructures, making upgrading or modifying them over their expected lifetimes (20 to 40 years) both problematic and expensive. Also, reduced procurement budgets and increased dominance of commercial technology cause acquisition managers to rely increasingly on commercial markets for affordable product development and support. So, as DoD's role shifts from being a technology producer to being a technology consumer, it relies more on commercial products whose design is not controlled by DoD and whose lifetimes are much shorter and more volatile than the weapons systems they support (e.g., years *vs.* decades). As a result, acquisition managers risk relying on unique products provided by a single supplier at high non-competitive prices and with little opportunity for technology insertion by other suppliers.

Here we discuss the need for a rigorous systems engineering process that incorporates open systems concepts and principles—where resulting system designs more readily accommodate changing technology to achieve cost, schedule, and performance benefits by

promoting multiple sources of supply and technology insertion.

THE NEED FOR AN OPEN SYSTEMS DESIGN APPROACH

An open systems design approach can allow a weapon system program office to achieve and maintain combat superiority in today's challenging acquisition environment. This approach focuses the design process on lowering the entire life-cycle costs (LCCs) of weapon systems—in contrast to current practice, in which a disproportionate focus is placed on the short-term goal of having the lowest development costs. Figure 1 illustrates that well over half of total LCCs are incurred post-IOC (initial operational capability) during the service lifetime (Defense Systems Management College, 1990). The ability of the open systems design approach to improve life-cycle supportability is becoming an even more important issue as DoD limits the number of new weapon systems procurements and extends the life of the systems currently fielded.

It seems clear that DoD managers should concentrate on doing things in systems engineering and development that will decrease costs during production and especially during the operations and support (O&S) phase. An open systems approach, basing the weapon system's design on open, commercially supported interface standards with the prospects of a large supplier and customer base, focuses the systems engineering process on developing system designs that consider life-cycle support requirements up front and that support system evolution throughout the system's life.

An open systems approach also mitigates the increased risks of obsolescence due to shortened technology cycle time. Obsolescence risks are significant because technology cycle time, sometimes on the order of months, far outpaces weapon system development cycle time, typically 8 to 15 years. By the time a system is fielded, supporting technologies are often outdated—the U.S. military cannot afford to be three or four technological generations behind what is available on the commercial market. Open systems designs, using commercially supported interface standards that permit upgrade at a relatively low cost, specifically address issues of affordability and supportability associated with long-lived systems by facilitating evolutionary upgrade with new technology. Generally, this results in superior combat capability over the total system life cycle, usually at a lower cost to the government.

Another reason that open systems have become so attractive is that DoD is no longer the dominant force in the marketplace and DoD's procurement budget has been drastically reduced. DoD no longer has the luxury of technology dominance, funded by seemingly unlimited budgets. In prior decades, DoD requirements drove development of new products and new technology. In today's environment the opposite is true; commercial demand drives product and technology development. However, DoD can now take advantage of commercial innovation, research, and development to drive down its cost of developing, acquiring, and maintaining weapon systems, leveraging the commercial investment to make the most of available and shrinking defense funds. An open systems approach, using

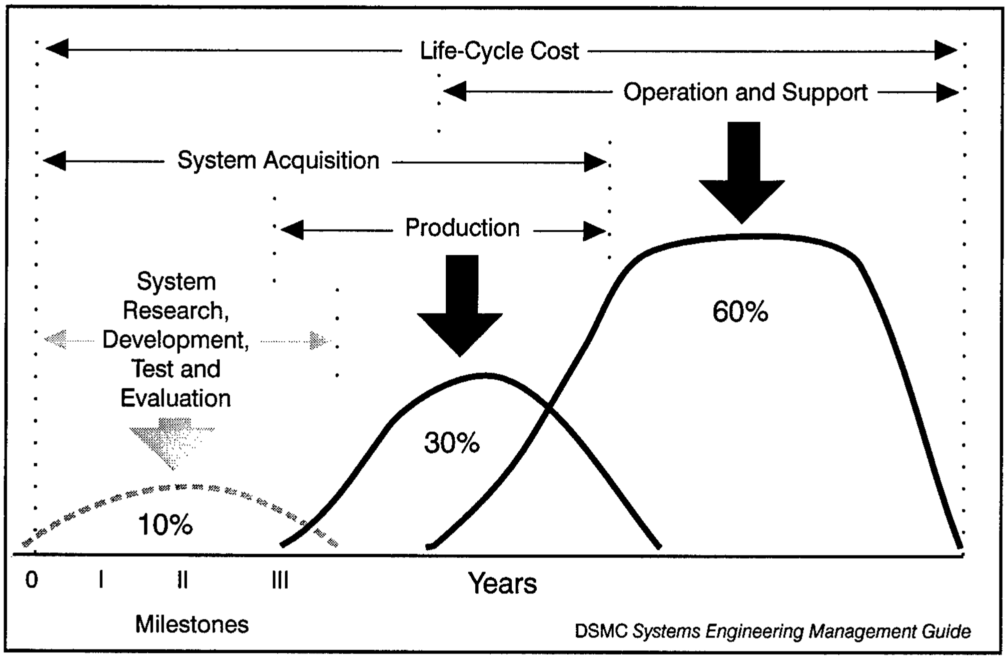


Figure 1. Life Cycle Costs

open interfaces supported by commercial and nondevelopmental components, can substantially facilitate this leveraging.

The bottom-line issue is not only cost: the lives of our servicemen may depend on shortened technology insertion cycle times. In a global market, everyone, including our potential adversaries, will gain increasing access to the same commercial technology base. The military advantage goes to the nation that has the best cycle time to capture the very best commercially available technologies, incorporate them in weapon systems, and get them fielded first. Moreover, since coalition operations with our allies place a high premium on interoperability, it is essential that our systems be compatible and capable of being sustained through a common logistics support structure. Open systems specifications and standards promote standard interfaces and interoperability with our friends and allies.

Each of these many issues will continue to substantively challenge past DoD acquisition practices throughout the foreseeable future. As a result, DoD finds itself with few alternatives but to drastically alter the way it develops, produces, and supports its weapon systems. It is neither economically nor technologically feasible to continue traditional closed design approaches. DoD is increasingly compelled to move toward a more open weapon systems design alternative.

Open Systems Design Concepts

Simply put, the concept of open systems is a commonsense approach that has substantial promise as a way to meet

DoD's continuing need to support systems over increasingly long life cycles in an environment of decreasing resources. At a time when the development of a complex system can span several generations of the faster moving technologies, open system architectures offer the tantalizing prospect of facilitating performance upgrades at affordable costs for the life cycle of the system. The potential and practice of open systems design as an emerging topic within the systems engineering discipline has now been with us for several years. In addition, the use of open systems has received the attention and support of the highest levels of DoD. In 1996, DoD issued a revised directive DoD 5000.2-R, which instructs program managers to employ open systems as a design consideration in defense systems engineering (DoD, 1998) This directive was subsequently revised and stengthened with Change 3 in March 1998. The systems engineering process, with specific reference to the consideration of open systems designs, is integral to achieving the benefits of open systems designs.

"Open systems are those that can be supported by the marketplace, rather than being supported by a single (or limited) set of suppliers, due to the unique aspects of the design chosen."

While there are many definitions of open systems, most have a few characteristics in common (Department of the Navy, 1993). Open systems are those that can be supported by the marketplace, rather than being supported by a single (or limited) set of suppliers, due to the unique aspects of the design chosen. Open systems architectures are achieved by having the design focus on commonly used and widely supported interface standards. One might think in terms of the axle-wheel-tire interfaces employed on commercial cars. By adhering to common standards at the interfaces, the consumer is able to buy tires from a multitude of suppliers, rather than being forced to buy from a single source, as might be the case if the interface characteristics were unique to a single supplier. This ensures costs and quality that are controlled by the forces of competition in the marketplace. Furthermore, the continued support of the system is not subject to the risks associated with having a single supplier go out of business or cease supporting the standard. As the technologies associated with tires change with time, the customer can continue to upgrade and support his vehicle with tires that are built to the accepted industry standard (e.g., from conventional sidewall bias-ply technology tires to steel-belted radial-ply technology tires).

But despite all the high-level attention on open systems, DoD program managers must exercise some care and judgment in their application of the open systems approach. It does not represent a new approach that replaces and makes obsolete previous approaches to engineering complex systems. Moreover, managers should not simply implement an open standard without careful consideration of where (in the system hierarchy) it makes sense to impose standards, nor should they simply grasp for a commercial item (CI) solution, whether or not the solution leads to the benefits of open systems architectures. Such actions may encourage program managers to declare that they are achieving open systems attributes,

whether or not the system design is well thought out to take full advantage of the benefits that the open systems approach offers. This may give the appearance of achieving open systems architectures but, in fact, such short-sighted decisions work against the long-term viability of the system. The open system concept does not replace the need for following a rigorous systems engineering process but, in fact, requires more rigor to ensure that open systems benefits are achieved.

Open Systems Applied Within the Systems Engineering Process

Systems engineering is fundamentally a problem-solving process that translates needs and requirements as inputs into designs and products as outputs. The systems engineering process typically starts with problem definition as requirements are analyzed. Alternative solutions or system architectures are developed, usually initially through techniques such as functional analysis and data flow analysis. Alternative physical designs are then developed to satisfy the functional or data flows. Trade studies and risk analyses are applied to select a preferred design solution, and that solution is verified against the original requirements.

This process, properly applied, results in a flow-down of requirements from the system level to the items below system level. As these requirements flow down, the design requirements for the items below system level are defined. Once these lower level design requirements are made final, the design process proceeds to completion. The result is a design that associates physical entities with the functions the system must perform, and is consistent with the levels of performance required and with the interfaces specified.

This process, applied without constraints, will lead to the design of a system in which every item is optimized to the requirements in terms of function, performance, and interface. Too often, the results in DoD have been systems that are unique in their designs, that perform their missions quite well, but that require unique equipment and parts to support them, and that can be supported only by a limited set of suppliers. This has historically been a prescription for closed systems that are both difficult and costly to support.

"Systems engineering is fundamentally a problem-solving process that translates needs and requirements as inputs into designs and products as outputs."

The challenge in DoD is to design systems to take advantage of open systems concepts where that makes sense, while continuing to meet the needs and requirements of operational forces. The solution is not to suddenly abandon good systems engineering and simply impose standard interfaces at some point in the system. Neither is the answer likely to be found in indiscriminately importing CI solutions into the system architecture. Rather, the solution is to perform good systems engineering while, as DoD dictates, employing open systems as a design consideration from the outset. The challenge, then, is to integrate systems engineering and open systems design.

To this end, the use of architectures in DoD has become a preferred management approach for implementing an open

systems approach (Under Secretary of Defense, 1996). DoD has implemented this concept by defining an interrelated set of architectures: operational, system, and technical (Figure 2). Basically, the operational architecture specifies the user requirements, which are used as inputs to the systems engineering process to eventually build the weapon system. The technical architecture and product lines constrain the system's design during the system engineering process. The system architecture emerges as an output and is constructed to satisfy operational architecture requirements within the rules and standards defined in the technical architecture. Technical architectures are particularly important to the systems engineering process because they provide the building codes for implementing systems upon which engineering specifications are based, common building blocks are built, and product lines are developed. Note that while each of these architectures by themselves builds nothing, together they provide a management tool that facilitates evolutionary acquisition by supporting insertion of new technology, component reuse, improved weapon systems interoperability, and the accommodation of evolving user requirements.

Who chooses the technical architecture? Does the government choose the architecture, does industry choose the architecture, or is the architecture chosen in concert? The government may specify key performance attributes of system building blocks including internal interface standards. But doing so without adequate input from industry stifles innovation, limits

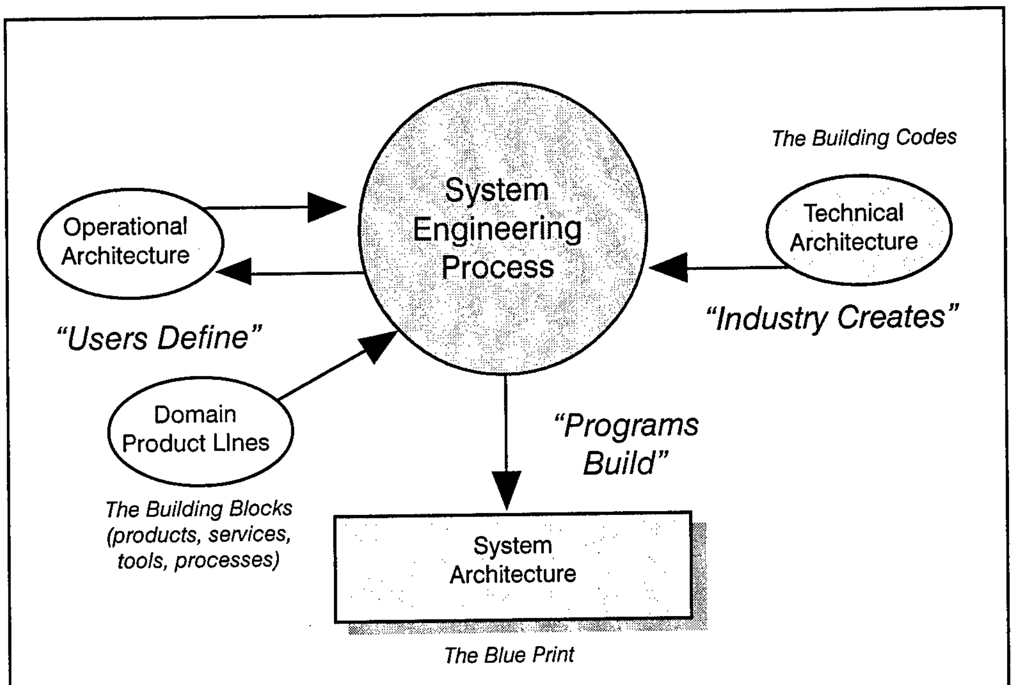


Figure 2. Architectures and the Systems Engineering Process

performance, and increases cost by attempting to substitute our wisdom for that of the designer. If, on the other hand, we provide no guidance, we may encourage development of proprietary architectures, interfaces, and components. That would leave DoD in a position where it must maintain and modify a unique product with a single supplier at a high, noncompetitive price. Each program must choose a path between these two extremes. A desirable situation is for consensus among potential prime contractors and their key suppliers on application of widely accepted standards.

Using an open systems approach to the systems engineering process helps achieve an integrated design solution that is resilient to changes in technology throughout the life of the system. Open systems engineering achieves this resiliency in life-cycle supportability by engineering systems according to the following principles and practices (Figure 3):

- Identify as critical the interfaces to subsystems or components that are likely to change due to their dependence on rapidly evolving technology, are likely to have increasing requirements, have high replacement frequency, or have high costs. Such components present both the highest obsolescence risks and the greatest opportunity for future technology insertion.

- Use open standards for these critical interfaces that are supported by the broader community, that are considerate of life-cycle support requirements, that

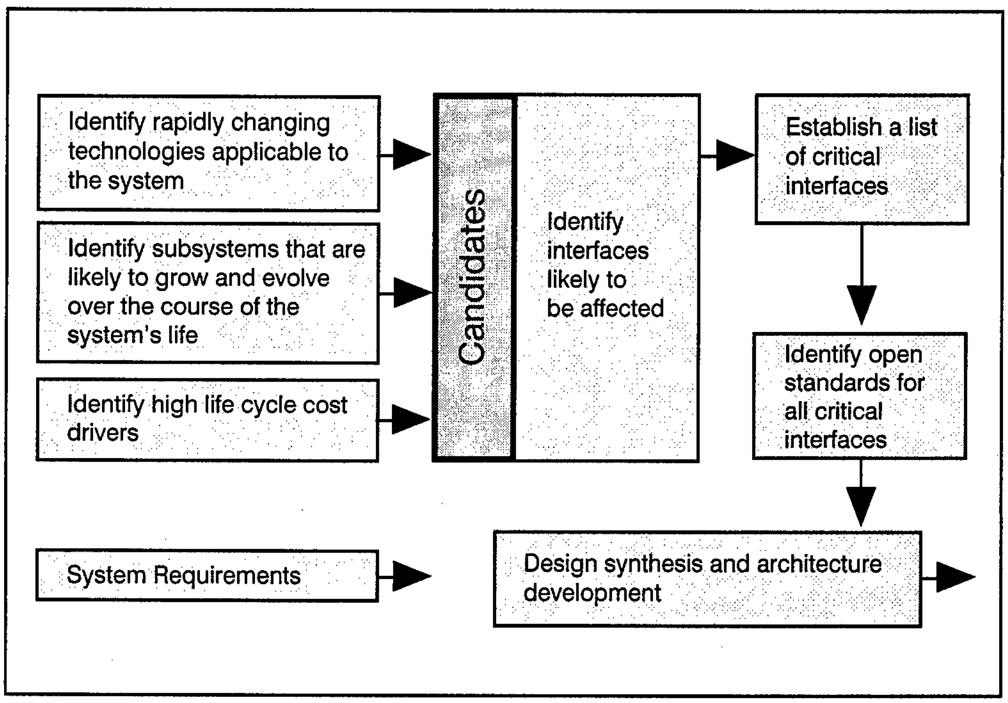


Figure 3. Open Systems Analysis for Integrated Design Solution

permit evolution with advances in technology, and that support technology insertion.

- Use a modular design approach combined with well-defined standards-based interfaces among modules to isolate the effects of change in evolving systems, serving to reduce the need for redesign as the system is upgraded.

- Identify the lowest level at which the government maintains control over the interface standard, and anticipate how this level may change over time. Below this level the contractor is permitted to use its best, perhaps proprietary, practices to improve or discriminate its product in the marketplace.

- Verify all performance requirements and reevaluate their stringency. Reallocation of requirements as necessary to permit the wider use of open standards throughout the system.

- Implement consistent conformance management practices to ensure that products procured for the system conform to the established profile, to prevent limitation to one supplier who might unilaterally extend that interface.

The key to achieving the benefits of open systems designs lies in making open systems an integral part of the classic systems engineering process and in applying open systems at all stages of the product life cycle. The open systems approach to design will never replace or make obsolete that process—if anything, it demands that the process be even more rigorously applied. As Figure 4 shows, each of the major aspects of the systems engineering process must include consideration of open systems design concepts and principles.

Requirements analysis must emphasize the balancing of business goals (costs, common use, life-cycle supportability, etc.) with technical goals (functionality, performance, interfaces, and other constraints). As the systems engineering process iterates, the requirements analysis step is revisited to consider cost-performance tradeoffs to meet most performance objectives while achieving as large as possible reductions in life-cycle costs. The stringency of requirements is reevaluated to consider the use of open standards for interfaces as performance requirements are balanced (weighed) against business requirements. To do this, engineers need to be better trained to incorporate life-cycle cost in design and to be provided with tools that allow them to rapidly assess life-cycle cost impacts. Under any circumstances, users need systems that are supportable and affordable, and these requirements demand that one consider open architectures as system elements are defined.

Functional analysis and allocation must define an architecture that provides a framework for identifying interfaces critical to achieving system business and technical performance goals. Requirements should be allocated with a view toward achieving functional modularity. Functional modularity can facilitate physical modularity and the use of open interfaces to support system evolution goals. As the systems engineering process iterates, this step is revisited to allocate functionality, to modularize those components or subsystems that are dependent on

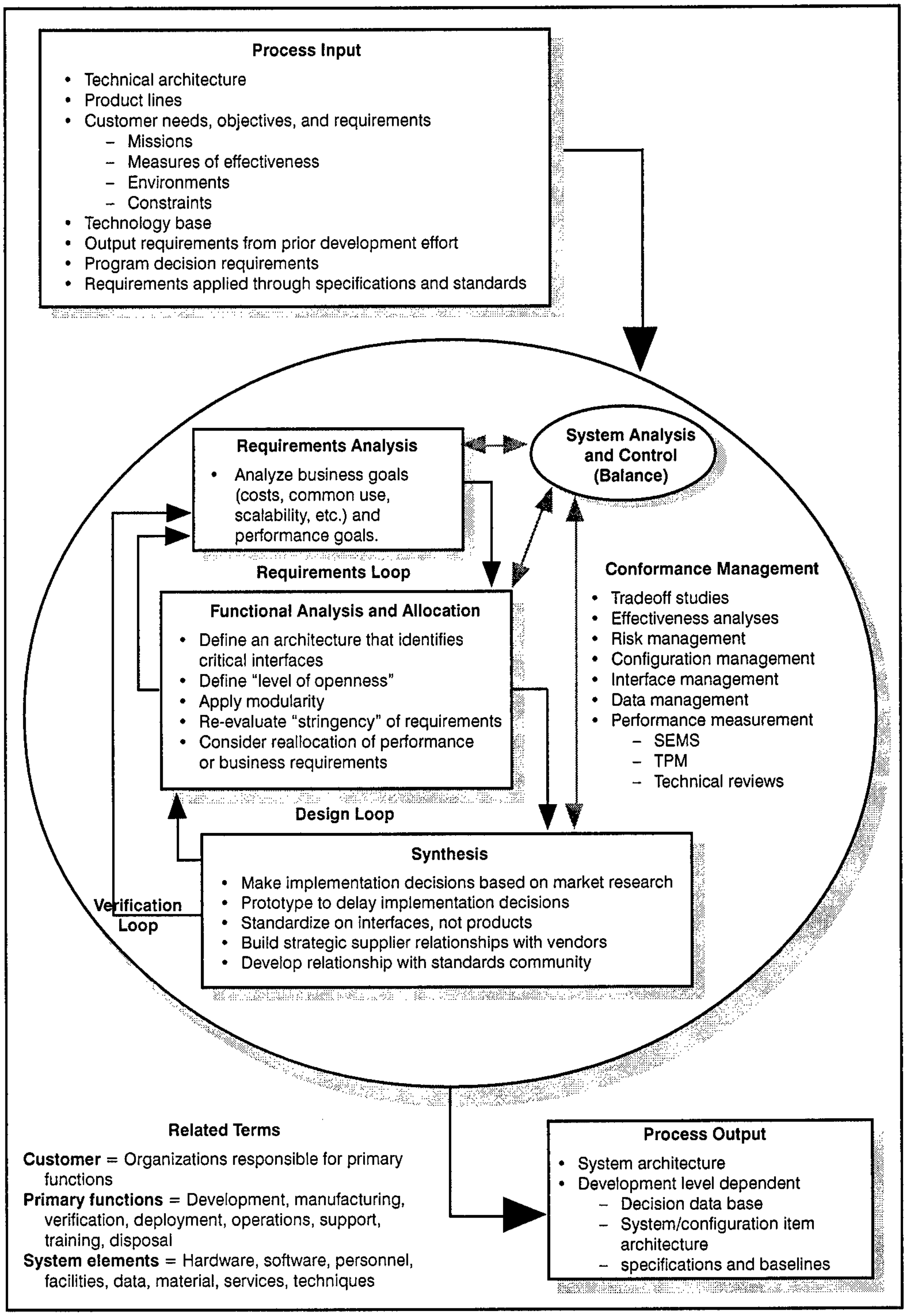


Figure 4.
Integrating Open Systems and the Systems Engineering Process

rapidly evolving technology, have high replacement frequency or are high cost, and to reallocate performance or business requirements as necessary to allow for the use of open interface standards during synthesis.

Synthesis and design should continue the search for alternative system architectures that will satisfy requirements. To be effective, good design synthesis demands an iterative approach that involves revisiting the functional allocations and developing alternative physical solutions until a balanced design (in terms of cost, performance, and risk) is achieved. Modularity should be used in system design where interfaces between modules are based on open, widely supported interface standards. Modularity should be based on well-defined interfaces to isolate components that are likely to change over time (e.g., those dependent on rapidly evolving technology or that have high replacement frequency) or are high cost, since these components present the highest obsolescence risks and the greatest opportunity for future technology insertion. Well-defined interfaces are used to decouple system components and define firewalls to contain evolution of lower level component upgrades and modifications, thereby minimizing future redesign, and possibly retesting, when components are upgraded. In addition, physical modularity should be aligned with functional partitioning to facilitate the replacement of specific subsystems and components without impacting others.

"To be effective, good design synthesis demands an iterative approach that involves revisiting the functional allocations and developing alternative physical solutions until a balanced design (in terms of cost, performance, and risk) is achieved."

Design iteration should sequentially reconsider the allocations of function and performance that define the design requirements for each system component with the objective of achieving user (customer) requirements within an optimal open systems solution. From an open systems perspective, if this sequential iteration is stopped as soon as the first acceptable technical solution is achieved, there are two probable results: either the solution will be shown to require unique designs that require new development, or an open solution, if imposed at this point, will likely not meet all the requirements of the user. However, in most cases, a final design can almost certainly be developed that results in system architectures that include some items that are open and other elements that are not. Although open designs are the objective, it is neither necessary nor in some cases even possible that every element or item of most complex systems be totally open.

Systems analysis and control must include conformance management, incorporating both implementation and applications conformance testing. The selected conformance approach must be fully defined and documented so that it is understood by all parties. The degree to which open systems benefits can be achieved will depend largely on how well the product design conforms to selected standards. Completely defined interface profiles will allow vendors to build standards-based components and allow users to design systems to use standards-based

components. In all cases, candidate components should be tested against detailed system profiles to ensure that components conform to profiles.

Open System Design Challenges

The open approach to system design offers considerable benefits, already discussed, in terms of life-cycle support, affordability, and timely technology insertion. The approach also carries with it some substantial differences in the way that systems will be managed and supported. Since by its nature open systems designs will involve increased use of commercial and nondevelopmental items in systems architectures, the government will necessarily have to plan for significant differences in the way systems are managed from a technical perspective. These differences cut across almost every aspect of engineering management, and while space prohibits an exhaustive treatment, examples include the following:

- Standards-based architectures lessen the degree of control that DoD can expect to exert. Changes, fixes, and updates will likely be under the vendor's control. This can have a significant impact on system support.

- Standards-based elements of the architecture are likely to be faster and cheaper to acquire than a comparable developmental item but may take more time to integrate and test.

- Standards selection is risky. Acquisition will require substantially more knowledge of the current state of the art and the marketplace on the part of the government.

- Standards evolve with time. It is difficult to project the extent to which a given standard will endure. It's equally challenging to determine when to move from one standard to the next.

- Standards-based architectures tend to change the focus of systems engineering from design to integration. The challenge is to achieve performance requirements without detailed control over the component design specification.

- An item, once integrated, may affect other system parameters. Commercial and nondevelopmental items make testing an ongoing and continuing activity to verify that items can integrate successfully into systems.

- The use of commercial and nondevelopmental items requires that support concepts be developed early in the acquisition cycle.

While this is hardly an exhaustive list, it makes the point that open systems engineering introduces new issues into the management of the technical aspects of programs. There are many potential benefits, but, likewise, there are challenges and problems that the manager must be alert to anticipate and overcome.

Summary

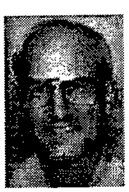
The objective of open systems acquisitions is to provide the warfighter with the

most effective weapon systems possible. An open systems approach to systems engineering facilitates this throughout the life of the system. Open systems designs provide an opportunity to achieve affordable designs that can more readily accommodate changing technology while promoting multiple sources of supply; however, to achieve good open systems designs first demands that a disciplined systems engineering approach be taken to define the appropriate elements in the system to be opened.

Most systems will not be completely open in their architectures, but a well-engineered design will result in a design strategy that takes maximum advantage of the benefits available from opening the design. Associated with an open approach is the need to focus on and manage the interfaces between open system elements and other elements of the system. Choosing well-known and accepted industry standards and applying them in a controlled manner will go far toward achieving the desired results. Overall, the system architecture resulting from a system engineering process should be linked to a business case analysis. Architecture decisions should be traceable to performance, life-cycle cost, schedule, and risk. The alternatives for support, maintenance, and upgrade should be evaluated.

For maximum benefit, an open systems approach should focus on planned use of designs across a system or domain. As designs are opened, managers must be aware of the fact that support and acquisition strategies will necessarily be affected. These impacts must be anticipated and planned for from the outset during system design.

COL J. Michael Hanratty is the deputy director of the Open Systems Joint Task Force, the Office of the Under Secretary of Defense (A&T), in Alexandria, VA. He has spent over half of his 26-year military career with the U.S. Army in the acquisition and the R&D fields. He holds a Ph.D. degree in electrical engineering from the Georgia Institute of Technology.
(E-mail address: hanratjm@acq.osd.mil)



Dr. Robert H. Lightsey is chairman of the Systems Engineering Department at DSMC, where he has taught for six years. Prior to that he was employed in a business headed by former Secretary of Defense William Perry. Dr. Lightsey was a career Air Force officer, where he served in both operational and acquisition positions. He retired in 1986 as a colonel.
(E-mail address: rhlights@dsmc.dsm.mil)

Dr. Arvid G. Larson is a program manager with Walcoff and Associates, Inc., in Alexandria, VA. With a 25-year professional career in systems R&D and applied computer technology, he has held technical and management positions with several leading R&D professional services and consulting firms. He holds a Ph.D. degree in electrical engineering from Stanford University.
(E-mail address: LARSONAG@acq.osd.mil)

References

Defense Systems Management College. (1990). Chapter 17: Life cycle costs. In *Systems Engineering Management Guide* (DTIC #ADA 223–168). Fort Belvoir, VA: Author.

Department of Defense. (1998, March 23). DoD Regulation 5000.2-R (Change 3, Paragraph 3.3.1, open systems, and Paragraph 4.3.4, open system design).

Department of the Navy, Office of the Assistant Secretary (RD&A). (1993, September 2). *Final report of the Tri-Service Open Systems Architecture Working Group* (see Appendix B, Definitions). Also see definitions on the OS-JTF home page at http://www.acq.osd.mil/osjtf.

Under Secretary of Defense (A&T) and the Assistant Secretary of Defense (C3I). (1996, August 22). Implementation of the DoD joint technical architecture (memorandum).

NOTE:

More open systems information and reference materials are available on the Open Systems Joint Task Force home page on the World Wide Web at http://www.acq.osd.mil/osjtf.

AN INVESTMENT-BASED APPROACH FOR MANAGING SOFTWARE-INTENSIVE SYSTEMS

Margaret E. Myers

Maintaining information superiority will be vital to the 21st-century warfighter, and the military's documented shortcomings in acquiring leading-edge information technology systems must be addressed in order to meet this need. The investment-based approach to the acquisition of software-intensive systems discussed here considers recent management reform legislation and will help DoD meet information superiority requirements.

In spite of numerous studies documenting the problems encountered in the acquisition of software-intensive systems, the defense acquisition community has not fully implemented the recommendations from those studies. As a result, the acquisition problems persist. Yet today's national security environment demands even more flexibility and responsiveness from the defense acquisition process, with software-intensive systems often on the leading edge of both the Revolution in Military Affairs and the Revolution in Business Affairs. This article recasts some of the historical recommendations in the light of recent management reform legislation and describes an investment-based management approach to the acquisition of software-intensive systems. Although the concepts described here are applicable to both hardware and software development, the scope of this article is limited to the management of systems with extensive software components, to include command and control systems, automated information systems, and other information technology investments.

WHY CHANGE IS NEEDED

The document *Joint Vision 2010* (Chairman of the Joint Chiefs of Staff, 1996) describes the future direction of our joint warfighting forces based on the emerging operational concepts of dominant

maneuver, precision engagement, focused logistics, and full-dimension protection. Execution of these concepts depends on our ability to achieve and maintain information superiority (CJCS, 1996):

> Sustaining the responsive, high-quality data processing and information needed for joint military operations will require more than just an edge over an adversary. We must have information superiority: the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.

The Department of Defense (DoD) Acquisition Year 2000 goal (Gore, 1997) of delivering new major defense systems to the users in 25 percent less time is especially relevant to implementation of Joint Vision 2010, which depends heavily on DoD's ability to leverage new and emerging technological opportunities. Unfortunately, the department's track record in keeping up with the rapid pace of advances in commercial information technology (IT) is not good, and many software-intensive systems fail to achieve their key performance parameters.

Although defense acquisition policy has evolved from the time when major defense acquisition programs were mostly hardware, the acquisition process still often requires extensive tailoring for software-intensive systems. However, very little guidance is available on how to tailor the policy for these systems. (See Appendix A for descriptions of various acquisition and software development models.) A different approach is needed for software-intensive systems, which must keep pace with technological advances while being responsive to the warfighter.

Implementing the management approach described here will support information superiority requirements by delivering software-intensive systems that are more responsive to the needs of the 21st century warfighter.

Proposed Management Approach

The following recommendations are based on an analysis of various acquisition and development models, legislation, policy guidance, and best practices relevant to software-intensive systems. The recommendations focus primarily on changes to the management and oversight processes since the technical implementation will, of necessity, vary from system to system.

Adopt an Investment Focus

For most acquisition programs, success is defined in terms of gaining Milestone III approval to produce and deploy the system, which is essentially a one-time event. A more appropriate perspective for software-intensive systems may be to view them as evolving capital assets that will provide a needed capability for some number of years. For software-intensive systems, that capability will be delivered incrementally to the user over the life of the investment. The key is to develop a long-term investment focus in support of goals that span the life of the program, not just to deliver a one-time product and walk away. This capital asset perspective is consistent with the Government Performance and Results Act (1993) and Office

of Management and Budget (OMB) capital planning guidance. (For more information on GPRA and the OMB Capital Planning Guide [OMB, 1997], see Appendix B.)

Define Investment Objectives

For DoD systems, the value of a capital asset should be measured in terms of its contribution toward achieving one or more goals in the DoD strategic plan (currently the Quadrennial Defense Review [QDR]) (Cohen, 1997). Given the proposed "evolving capital asset" perspective described above, the requirements and acquisition communities should jointly develop intermediate investment objectives that are acceptable to the user and technically feasible. The acquirer subsequently translates these objectives into capability packages that, when deployed, demonstrate measurable progress toward meeting the DoD strategic goals. The system developer derives the specific technical requirements for each capability package based on the user's objectives. When deployed, each capability package should demonstrate measurable progress toward achieving the intermediate objectives and, ultimately, the strategic goals.

The key is for management to be able to maintain traceability from the Joint Vision 2010 concepts, to the DoD strategic plan and supporting strategic goals, to the investment objectives, and finally to the implementing capability packages. The challenge lies in defining investment objectives that are measurable and preferably quantifiable. The health affairs community is probably the leader in holding its management accountable by measuring progress against strategic goals and investment objectives. Defining system-level objectives and linking them to corporate strategic goals are key tenets from the GPRA, Clinger-Cohen Act of 1996, and OMB guidance. (See Appendix B for more information on the Clinger-Cohen Act.)

Build an Investment Framework

The decision to invest in a software-intensive capital asset should initiate planning for an investment framework (business model) to manage that asset during its useful life. This framework should include not only the operational and technical architectures that will define how the capital asset will be used and built, but also repeatable processes for updating the investment objectives, negotiating the scope of each increment, evolving the software components, managing the risks, and measuring the outcomes. For deeply embedded applications, a DoD-driven domain analysis and architecture are essential, with an emphasis on classic software reuse paradigms; for many information systems, a market-driven analysis and architecture that can leverage the commercial sector may be more appropriate. For command and control systems, a hybrid approach is usually required to deal with acquiring and integrating commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) applications into custom-developed software. Some of the challenges for hybrid systems include modification of COTS packages to interoperate with custom-

"The challenge lies in defining investment objectives that are measurable and preferably quantifiable."

developed software; the resulting maintenance, licensing, and ownership issues; synchronization of changes with existing GOTS software that will continue to evolve independently; and ground rules for each increment to retain maximum flexibility for future design and requirements changes.

From a management and oversight perspective, building the investment framework to support the production of follow-on increments should be just as important as deploying the first increment. The investment framework is analogous to establishing a software production line to streamline the development of following increments; this approach was successfully demonstrated in the Software Technology for Adaptable, Reliable Systems (STARS) project sponsored by the Defense Advanced Research Project Agency (Institute for Defense Analysis, 1996). The concept of an investment framework is consistent with the Clinger-Cohen Act, which mandates an integrated technology architecture. (For more information on architectures for software-intensive systems, see Appendix C; for more information on software product lines, see Appendix A.)

"The goal should be to deliver small, compatible increments that provide useful, added capability every 6 to 18 months."

Constrain Increment Size

A tenet of recent legislation and guidance is that information technology systems should "be implemented in phased, successive segments as narrow in scope and brief in duration as practicable, each of which solves a specific part of an overall mission problem and delivers a measurable net benefit independent of future segments" (Raines, 1996). One of the lessons learned from program managers who have implemented software-intensive systems based on the incremental or evolutionary models is that the first increment typically fails to meet its cost, schedule, and performance parameters because the scope is too broad. This usually happens because the user is unwilling to constrain the requirements because of fears that follow-on increments won't be delivered.

Adopting a capital asset perspective and constraining increment size should shift the focus from one of demanding full capability in the first increment to defining the minimum useful capability for the first and each subsequent increment. The goal should be to deliver small, compatible increments that provide useful, added capability every 6 to 18 months. The Global Command and Control System (GCCS), for example, is currently on an 18-month schedule for deploying major releases, with smaller beta releases in-between. The Army Tactical Command and Control System (ATCCS) currently plans to deploy new software increments approximately every 12 months. Smaller increments reduce risk, minimize schedule delays, and avoid cost overruns. This is consistent with the Clinger-Cohen Act and OMB guidance.

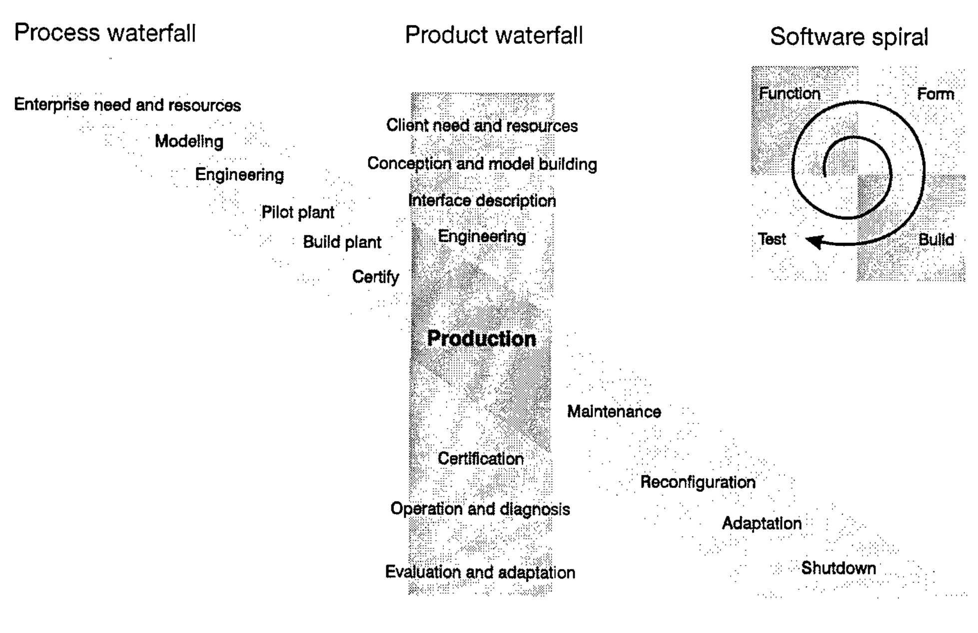
Apply the Spiral-to-Circle Model

Rechtin and Maier (1997) discuss the differences between the waterfall model, which aptly fits the largely irreversible steps of hardware acquisition, and the spiral model, which better represents the

iterative process of software development (Figure 1). Although current defense acquisition policy strongly supports tailoring, most acquisition strategies resemble the waterfall model rather than the spiral model. After analyzing the structural dissimilarities between the two models and the problems that result when coordinating hardware and software development, Rechtin and Maier recommend use of a single spiral-to-circle model (Figure 2).

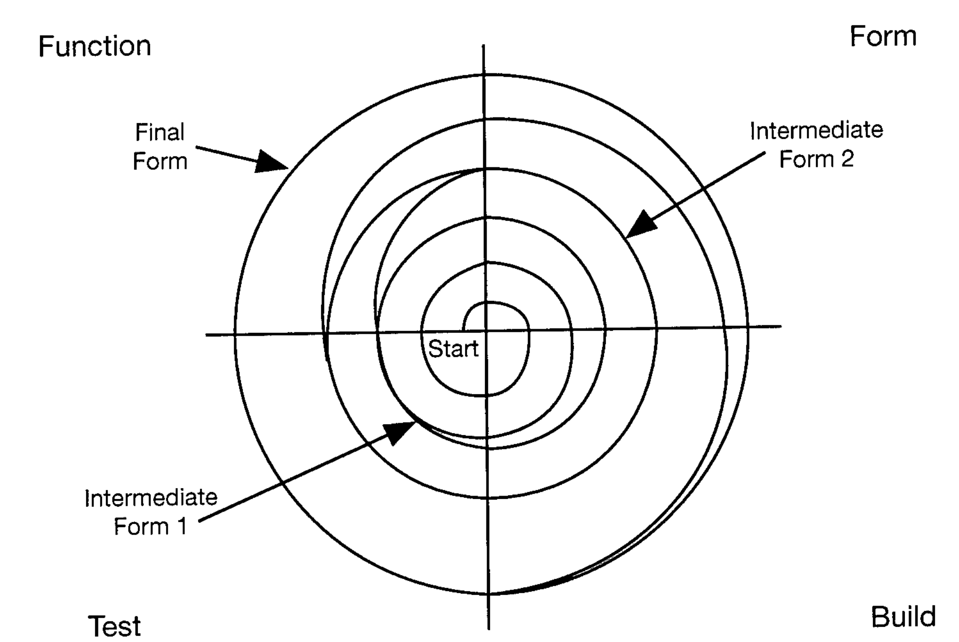
This model is based on the following heuristic: "Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not." For software development, the spiral-to-circle model implies pausing on the outward spiral by entering a closed circle for a stable version, which could be deployed and which would form the baseline for the next increment of functionality. For hardware development, the model implies a hold after each step to review progress. For combined hardware and software development, the closed circles represent the points at which stable hardware and software configurations come together for testing and potential deployment.

The spiral-to-circle model appears to be a useful management tool whenever it is necessary to integrate hardware and software components in the same system. The model is also applicable to hardware-intensive systems that are developed using simulation-based acquisition methodologies. Additionally, the model should be a



Source: *The Art of Systems Architecting*, by E. Rechtin and M. Maier, 1997, CRC Press.

Figure 1. Waterfall and Spiral Models



Source: *The Art of Systems Architecting*, by E. Rechtin and M. Maier, 1997, CRC Press.

Figure 2. The Spiral-to-Circle Model

useful integration tool when commercial items or other nondevelopmental items are used in lieu of developing new components. (For more information on the spiral-to-circle model, see Appendix A.)

Investment Management Issues

The investment-based approach just described (adopt an investment focus, define investment objectives, build an investment framework, constrain increment size, and apply the spiral-to-circle model) is intended to support information superiority requirements by delivering software-intensive systems that are more responsive to the needs of the 21st-century warfighter. To accomplish this, the approach must address three areas related to investment management of software-intensive capital assets. First, are the management issues associated with designing, developing, and deploying the core increment that will provide the initial operating capability? Second, are the issues associated with managing the follow-on increments? (These issues endure for the life of the system.) Third, are the interoperability issues that arise in coordinating the design, development, and deployment of increments from multiple systems (systems of systems)?

Core Increment Issues

Adopting the capital asset investment approach with its emphasis on up-front planning will require increased participation

from the requirements (user) community, especially in defining the investment objectives and constraining increment size. One way to ease this burden would be to appoint an acquisition-qualified program manager to coordinate the planning activities before the investment is approved as an acquisition program. This, in turn, would require some additional training for the program manager and might conflict with current initiatives to reduce the size of the acquisition workforce.

Building the investment framework is not trivial. The GCCS evolutionary acquisition process appears cumbersome to those who see it for the first time, but it was invented by the GCCS integrated product team members (who received the Defense Acquisition Executive Award for Acquisition Excellence for their initiative), and it seems to work effectively for GCCS. Unless the investment framework processes for other programs are carefully established and the people are effectively trained, the software-intensive capital asset concept is no better than current acquisition approaches. (For additional information on GCCS, see Appendix C.)

Follow-on Increment Issues

Once the investment framework is effectively established and has been proven to work on the first increment, follow-on increment development should have lower risk, especially if the increments are schedule-constrained. The Milestone Decision Authority should consider delegating follow-on deployment decisions, but some limited oversight may be required to ensure that the process remains disciplined.

Software-intensive systems that have already deployed their core increment are candidates for conversion to the investment approach once they have established an appropriate investment framework, to include a current baseline. The GCCS evolutionary acquisition process, for example, was developed after the core increment was deployed.

Systems of Systems Issues

The investment framework must include a process for ensuring interoperability with other systems and increments from other software-intensive capital assets. This is especially critical in supporting the Joint Vision 2010 requirement for information superiority. The Army uses the spiral-to-circle model to address synchronization issues associated with the Army Battlefield Control System (ABCS). The ABCS component systems must successfully complete a synchronization event to demonstrate interoperability before deployment. Beta sites and test beds are also useful tools for validating interoperability before deployment. Constraining increment size should be conducive to scheduling synchronization events and establishing OT&E test windows, in which multiple systems have an opportunity to jointly test their newest increments before full deployment. (For more information on operational test and evaluation [OT&E] strategies for software-intensive systems, see Appendix C.)

"The investment framework must include a process for ensuring interoperability with other systems and increments from other software-intensive capital assets."

Process Changes Required for Implementation

Implementing the investment-based approach described here will require acquisition, requirements, and PPBS process changes, to include changes in policy, guidance, and training.

Acquisition Process

The recommendations suggested above are consistent with defense acquisition policy, which allows for extensive tailoring. However, the proposed approach should be documented in the *Defense Acquisition Deskbook* (DAD, 1998) as a DoD-wide best practice and updated with implementation lessons learned.

Implementing the concepts described above will not work without an investment in education and training for program managers, their staffs, and other personnel in the acquisition chain. Team training for the participants in each specific project may be the most efficient way to introduce these new concepts. Specific topics that must be addressed include the GPRA, the Clinger-Cohen Act, OMB capital asset guidance, architectures, and software management issues, to include the use of software process and product quality measures. The Software Engineering Institute's software capability maturity model (CMM) and software acquisition CMM are examples of models that can be used to promote the process improvements needed to build and manage an investment framework.

"The acquisition community must partner with the Joint Staff to jointly identify needed changes to the requirements process in support of the software-intensive capital asset approach."

Requirements Process

The acquisition community must partner with the Joint Staff to jointly identify needed changes to the requirements process in support of the software-intensive capital asset approach. One of the key lessons learned and relearned in the acquisition of software-intensive systems is the need to involve the real end user, both in helping to refine the specific requirements and in assessing how well those specific requirements, as they are implemented, meet their needs. The GCCS beta release strategy mentioned previously allows users to experiment with new applications on a trial basis; only those applications that the users want are incorporated into the next major release. The GCCS evolutionary acquisition strategy supports this flexible approach to requirements generation, but most major acquisition programs do not have this flexibility.

Planning, Programming, and Budgeting System (PPBS) Process

The comptroller and the acquisition community should jointly identify needed changes to the PPBS process to support the software-intensive capital asset approach. To best implement the approach described here, program managers need a guarantee of program stability and a steady-state funding stream. The comptroller should also work with OMB to ensure that the proposed investment process is implemented consistently with OMB guidance.

Other Implementation Suggestions

In addition to integrating necessary changes into the acquisition, requirements, and PPBS processes, it may be necessary to charter a multifunctional process action team to develop the policy, guidance, and training required to implement the proposed approach. One or more pilot programs would be useful for maturing the new processes and demonstrating the improvement.

Conclusion

This investment-based approach to the acquisition of software-intensive systems meets information superiority requirements, while complying with recent management reform legislation. The proposed approach is based on five key recommendations: adopting an investment focus, defining investment objectives, building an investment framework, constraining increment size, and applying the spiral-to-circle model. The approach can be adapted to address issues related to core increments, follow-on increments, and systems of systems. Successful implementation will require coordinated changes to the acquisition, requirements, and PPBS processes and a better understanding of how to tailor acquisition strategies. These changes, however, are essential to delivering software-intensive systems that are more responsive to the needs of the 21st-century warfighter.

Margaret E. Myers is the director of performance assessment for the Office of the Assistant Secretary of Defense (OASD) for Command, Control, Communications, and Intelligence (C3I). She was previously the director of acquisition oversight for the OASD(C3I) and served as acting Deputy Assistant Secretary of Defense for C3I Acquisition. Other prior positions include deputy commander and technical director of the U.S. Army Operational Evaluation Command (OEC), director of information mission area systems evaluation (OEC), deputy director of command control, communications, and computer (C4) systems evaluation (OEC), and chief, Systems Performance and Special Projects Division for the Army Information Systems Engineering Command.

Her current responsibilities include independently assessing DoD information technology (IT) performance to ensure that investments are consistent with DoD policies and plans and provide measurable improvements; formulating DoD IT acquisition policy applicable to all DoD components; planning and coordinating the IT acquisition review process for the OASD (C3I); and coordinating the Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) Cooperative Research Program.

She earned a B.A. degree in mathematics from Colorado College, an M.S. degree in operations research from American University, and a Ph.D. degree in information technology from George Mason University.
(E-mail address: margaret.myers@osd.pentagon.mil)

References

Boehm, B. (1988, May). A spiral model of software development and enhancement. *Computer*. Vol. 21, No. 5. The Institute of Electrical and Electronics Engineers, Inc.

Chairman of the Joint Chiefs of Staff. (1996). *Joint vision 2010.* Washington, DC: GPO.

Clinger-Cohen Act of 1996, Pub. L. 104-208, 104th Congress. (Formerly the ITMRA.)

Cohen, W. S., U.S. Department of Defense (1997). *Report of the quadrennial defense review.* Washington, DC: GPO.

Defense acquisition deskbook (1998). [On-line and CD-ROM]. Available http://www.deskbook.osd.mil

Gore, A. (1997). *DoD acquisition reinvention impact center goals.* Washington, DC: GPO.

Government Performance and Results Act of 1993, Pub. L. 103-62, 103rd Congress.

Information Technology Management Reform Act of 1996 (ITMRA), Pub. L. 104-106, 104th Congress.

Institute for Defense Analysis. (1996). *The cost and benefits of domain-oriented software reuse: Evidence from the STARS demonstration projects* (IDA Paper P–3191). Alexandria, VA: Author.

Office of Management and Budget. (1997). *Capital planning guide* (Supplement to Circular A–11, Part 3). Washington, DC: GPO.

Raines, F. D. (1996). *Principles of budgeting for capital asset acquisitions.* Washington, DC: Office of Management and Budget.

Rechtin, E., & Maier, M. W. (1997). *The art of systems architecting.* Boca Raton, FL: CRC Press.

APPENDIX A

ACQUISITION AND SOFTWARE DEVELOPMENT MODELS

ACQUISITION PROGRAM STRUCTURE MODELS

The following information is extracted from the *Defense Acquisition Deskbook (1998)*. The program structure is the fundamental building block of the program's acquisition strategy, where "program structure" means the phases and milestone decision points established for a program. The program structure models described below, when appropriately tailored, are suitable for the vast majority of major programs. One of the major themes in the current version of the DoD 5000 policy is that Milestone Decision Authorities (MDAs) "should strive to tailor most aspects of the acquisition process, including program documentation, acquisition phases, and the timing, scope, and level of decision reviews."

Traditional model. This model is the four-milestone, four-phase process that represents the department's typical approach to major acquisition development programs. Because of its widespread use, statutory requirements tend to be associated with this model's phases and milestone decision points.

Grand design model. This model is characterized by acquisition, development, and deployment of the total operational capability in a single increment. The required operational capability can be clearly defined and further enhancement is not foreseen to be necessary. The grand design model is most appropriate when the user requirements are well understood, supported by precedent, easily defined, and assessment of other considerations (e.g., risks, funding, schedule, size of program, or early realization of benefits) indicates that a phased approach is not required.

Incremental model. The incremental model is generally characterized by acquisition, development, and deployment of capability through a number of clearly defined system increments that stand on their own. The number, size, and phasing of the increments required for satisfaction of the total scope of the stated user requirement should be defined by the program manager, in consultation with the user. An incremental model is most appropriate when the user requirements are well understood and easily defined, but assessment of other considerations (e.g., risks, funding, schedule, size of program, or early realization of benefits) indicates a phased approach is more prudent or beneficial. An example of this model is pre-planned product improvement.

Evolutionary model. This model is characterized by the design, development, and deployment of a preliminary capability using current technology that includes provisions for the evolutionary addition of future capabilities as requirements are further defined and technologies mature. The evolutionary model differs from the incremental model in that the total functional capability is not completely defined at inception, but evolves as the system is built. This model offers an alternative to the traditional model for those programs not requiring a leap in technology, where the design process includes technology maturation, and where a program can

make use of an interim solution with successive upgrades.

Advanced concept technology demonstrations (ACTDs) and evolutionary models share some similarities in that both involve short cycle times and address a requirement for state-of-the-art technology. ACTDs, however, are oriented to the development of an operational concept and do not necessarily result in a production program. Evolutionary models are oriented toward production from the beginning. (Note: The *Defense Acquisition Deskbook* contains several excellent sources of additional information on the evolutionary model, including the DSMC *Guide for Evolutionary Acquisition,* the Australian Defence Department handbook, and the *Global Command and Control System Lessons Learned.*)

Other program models. The models described above may be tailored to support commercial item and nondevelopmental item acquisitions.

Development Models

The following descriptions of the waterfall, spiral, and spiral-to-circle models are extracted from *The Art of Systems Architecting* by Rechtin and Maier (1997).

Waterfall model. The waterfall model describes a sequence of largely irreversible steps especially typical of hardware acquisition and production plant construction. Although the waterfall method is less appropriate for software development, it is sometimes used for software-intensive systems.

Spiral model. The iterative process of software development is better represented by a spiral expanding through four quadrants: function, form, build (code), and test. In the DoD environment, function equates to requirements definition; form equates to design; build equates to development; and test equates to test and evaluation. In this model continually expanding software versions are based on learning from earlier development.

The spiral model is attributed to Boehm (1988), who developed and applied the model to large government software projects while working for TRW. The spiral model creates a risk-driven approach to the software process, rather than primarily a document-driven or code-driven process. Each cycle of the spiral begins with the identification of the objectives of the portion of the product being elaborated (performance, functionality, ability to accommodate change, etc.); the alternative means of implementing this portion of the product (design A, design B, reuse, buy, etc.); and the constraints imposed on the application of the alternatives (cost, schedule, interfaces, etc.). The following steps evaluate the alternatives, and identify and resolve risks; develop and verify the next-level of product; and plan the next phases.

Spiral-to-circle model. This single-process model accommodates the imperatives of both the hardware and software development processes based on the following heuristic: Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not. In hardware development, the model implies scheduled holds at the end of each step in the sequence to review the development and to determine that the integrity of the system concept has not been violated (everything necessary has been done and nothing unnecessary has been added). In

software development, the model implies pausing in the outward spiral from time to time by going into a closed circle to create a stable version.

Because the spiral-to-circle model is a single model, it implies that the intermediate form is not only stable, but could also usefully continue as a product indefinitely (even as an acceptable end point should budget constraints or operational needs so dictate). Meanwhile, research, development, analysis, prototyping could continue to cycle on that circle until the decision is made to expand outward to new functions and forms.

Software product line model. Software product lines are software systems that share a set of common attributes (e.g., functionality, architecture, design, components/modules, development/maintenance processes). With these common attributes as a foundation, unique systems can be built to satisfy specific customers' requirements. The product line model was prototyped by the Defense Advanced Research Projects Agency (DARPA) software technology for adaptable, reliable systems (STARS) program. The STARS pilots successfully demonstrated the benefit of developing a common architecture and standards within a software domain (i.e., command and control) and then exploiting that common base to significantly reduce the design, development, and testing time for follow-on applications in that domain. More information on the STARS project is available on the World Wide Web at http://www.asset.com/stars/. The Defense Information Infrastructure Common Operating Environment (DII COE) is a product line focused on the infrastructure (vice application) level.

Appendix B

GPRA, Clinger-Cohen Act, and OMB Implementing Guidance

Government Performance and Results Act

The Government Performance and Results Act (GPRA) of 1993 required agencies to submit strategic plans to the Office of Management and Budget (OMB) by September 30, 1997. The plans were to include:

- a comprehensive mission statement for major functions and operations of the agency;
- general and outcome-related goals;
- a description of how the agency will achieve the goals and the operational processes and resources required;
- a description of how the goals relate to annual performance plan goals;
- an identification of key factors external to, and beyond the control of, the agency that could significantly affect the achievement of goals; and
- a description of program evaluations the agency used in establishing and revising general goals, with a schedule for future program evaluations.

The DoD Strategic Plan is the Quadrennial Defense Review.

Clinger-Cohen Act

The purpose of the Clinger-Cohen Act of 1996 is to improve the productivity, efficiency, and effectiveness of federal programs through the improved acquisition, use, and disposal of information technology (IT) resources. Among other provisions, the law requires executive agencies to design and implement a process for maximizing the value and assessing and managing the risks of IT acquisitions. The Clinger-Cohen Act also streamlines the IT acquisition process by encouraging the adoption of smaller, modular IT acquisition projects. With certain exceptions, the Clinger-Cohen Act is generally applicable to National Security Systems.

OMB Capital Planning Guidance

The OMB *Capital Planning Guide* (Supplement to Circular A–11, Part 3) integrates various asset management initiatives (GPRA, Clinger-Cohen Act, etc.) into a single, integrated capital planning process to ensure that capital assets contribute to the achievement of agency strategic goals and objectives. The definition of capital assets includes IT hardware, software, and modifications; and DoD weapons systems. The four phases of the capital planning process are planning, budgeting, procurement, and management-in-use.

In the planning phase, the intent is for strategic plans, annual performance plans, and plans for capital assets to flow from the same process for identifying a baseline of current performance and the gap

between current and planned performance; functional requirements for bridging this gap; alternatives for meeting these functional requirements; the best capital asset solution if one is needed; and a summary of proposed funding, procurement, and management of each capital asset within the agency's portfolio of assets in an agency capital plan. The acquisition strategy and risks are part of the information provided when seeking approval of a project.

Although budgeting begins in the planning phase, the formal start of the budgeting phase is the agency's request to OMB for asset acquisition. Agency budget submissions should be consistent with the "Principles of Budgeting for Capital Asset Acquisitions," which was published with the fiscal year 1998 budget. DoD guidance for implementing these principles is documented in the May 1, 1997, Office of the Secretary of Defense memorandum, "Requirements for Compliance with Reform Legislation for Information Technology (IT) Acquisitions (Including National Security Systems)." The budgeting phase ends when Congress appropriates funds for the acquisition and OMB apportions the funds to the agency.

OMB's procurement phase is essentially equivalent to the DoD acquisition process. Key steps in this phase are to:

- validate the planning decision;
- manage the procurement risk;
- consider tools (modular contracting, two-phased acquisition, competitive prototyping);
- select contract type and pricing mechanism;
- issue the solicitation;
- conduct proposal evaluation and negotiation;
- award the contract;
- manage the contract;
- conduct acquisition analysis; and
- conclude with acceptance (testing).

The management-in-use phase includes the steps an agency should take to manage and evaluate the continued viability of an acquired capital asset as part of the agency portfolio. The steps in this phase include:

- operational analysis (which can be used to minimize the cost of asset ownership while simultaneously improving the function the asset performs);
- execution of the operation and maintenance plan;
- post-implementation review (to evaluate the overall effectiveness of the agency's capital planning and acquisition process); and
- execution of the asset disposal plan.

APPENDIX C

OTHER RELEVANT GUIDANCE AND BEST PRACTICES

ARCHITECTURE SYNCHRONIZATION

DoD has adopted the concept of multiple, linked architectures to describe the operational, system, and technical views of information technology-based systems. Comprehensive DoD-wide architectural guidance is described in the Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework Version 2.0, which was approved for implementation in February 1998. Version 2.0 of the C4ISR Architecture Framework is available at http://www.cisa.osd.mil.

The following architecture descriptions are from various DoD architecture Web pages.

Operational architecture. An operational architecture is a set of elements consisting of information exchange requirements, mission area interactions, tasks, interoperability tables, logical connectivity, and a description of the environment where the information system is to be operated. The operational architecture is tied to both the systems and technical architectures and provides a disciplined approach or methodology to review baseline requirements, assess doctrinal impacts, examine and assess alternatives through excursions (functional or process improvements; and doctrine, training, leader development, organization, materiel, and soldiers [DTLOMS] requirements). An operational architecture:

- identifies the mission objective;
- identifies information exchange requirements;
- identifies logical connectivities; and
- identifies operational elements.

Systems architecture. A systems architecture view is a description, including graphics, of systems and interconnections providing for or supporting warfighting functions. It is a representation that associates physical systems and their performance attributes to the operational architecture and is built following the standards in the technical architecture. A systems architecture:

- maps information exchange requirements;
- defines connections between components;
- defines capacity;
- defines performance; and
- defines constraints.

Technical architecture. A technical architecture is a minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements that together may be used to form a system, and whose purpose is to ensure that a conformant system satisfies a

specified set of requirements. A technical architecture identifies the services, interfaces, standards, and their relationships. A technical architecture:

- defines systems rules;
- establishes standards for interoperability; and
- applies technology references that influence architecture decisions.

(Note: The Joint Technical Architecture is mandatory for all C4I systems.)

Flexible OT&E Strategies

OT&E strategy for software-intensive systems. Since 1992, the Army has used a flexible operational test and evaluation (OT&E) strategy to support faster fielding of software-intensive systems that have been divided into blocks of functionality (increments). The strategy allows partial fielding of software-intensive systems, once successful OT&E of a representative sample has been accomplished. A representative sample is the portion of the software to be developed that demonstrates the ability of the hardware, commercial off-the-shelf (COTS) software, and communications network to support the total system requirements. The strategy is applicable both to weapon systems with extensive embedded software and information systems. The approach supports multiple software development models, enhances the program manager's acquisition strategy, and reduces the risk to the warfighter and the decision maker.

OT&E guidelines for software-intensive system increments. In October 1996, the Office of the Director of Operational Test and Evaluation (DOT&E) published guidelines intended to streamline the OT&E process and to achieve "affordable confidence" for the development and procurement of software-intensive systems. The guidelines apply to increments of software-intensive systems acquired subsequent to deployment of the "core block," which undergoes full operational testing. For insignificant to moderate risk increments, these guidelines streamline the OT&E process by reducing the degree of testing. The guidelines are applicable to both the incremental and evolutionary models.

OT&E test windows. One of the issues that the 1989 Army Science Board Summer Study on the Army Tactical Command and Control System (ATCCS) addressed was how to synchronize changes to the component ATCCS programs after the core systems were deployed. The recommended solution was to establish operational test "windows" that would be scheduled once or twice a year so that developers could ensure continued interoperability and minimize operational risk before deploying follow-on increments. The Army Program Executive Office for Command, Control, and Communications Systems has recently proposed a similar process to synchronize the development, testing, and fielding cycles of the Army Battlefield Command System component systems.

Blocked ORDs

Users occasionally write operational requirements documents (ORDs) that divide the requirements into "blocks" for incremental design, development, and

deployment, but there is currently no explicit guidance on how to "block" ORDs. Several years ago, the automated information systems community proposed an approach by which the user and program manager would work together to sectionalize the ORDs, relying on the user's operational (functional) knowledge and the program manager's technical knowledge. The premise was that a viable acquisition strategy requires an ORD that can be implemented both technically and operationally. If not done collaboratively, the user may propose a solution that is not technically viable; conversely, the program manager may propose a technical solution that cannot be implemented operationally. The proposal also included suggestions for defining system increments in terms of functionality, user class or echelon, or operational mode.

GLOBAL COMMAND AND CONTROL SYSTEM

The Global Command and Control System (GCCS) has implemented an evolutionary acquisition strategy that integrates the requirements and acquisition processes to ensure the early, concurrent consideration of operational, technical, procedural, test, support, and fiscal issues within the GCCS stakeholder community. The *Defense Acquisition Deskbook* has information on the GCCS evolutionary acquisition process. Additional information is contained in an Institute for Defense Analysis paper that describes how the integrated product team process and DoD 5000 series policy were tailored to accommodate the evolutionary nature of GCCS. The IDA paper is available on the Web at: http://www.ida.org/DIVISION/sfrd/IDA_Papers_Documents.html.

Acknowledgments

This work was supported by the Office of the Assistant Secretary of the Army for Research and Development.

I thank Herb Fallin for his guidance in this project and Walt Hollis for his support. I also thank the following individuals for their ideas and comments on the concepts and draft paper: Linda Brown, Bill Campbell, Hoss Cartwright, Dan Czelusniak, Ron Garant, Jerry Garretson, Rick Johnson, Boyd Jones, Bob Kern, Jim Linnehan, Scott Lucero, Fred Myers, Lloyd Pickering, Tom Purdue, Al Resnick, Pat Sanders, George Schneiter, Robert Schwenk, Doug Sizelove, and Cindy Trackwell.

Correspondence should be addressed to Margaret E. Myers, OASD(C3I), 6000 Defense Pentagon, Washington, DC 20301.

"SUBCONTRACTING" AS A SOLUTION, NOT A PROBLEM, IN OUTSOURCING

William N. Washington

As outsourcing has come into vogue for both commercial and government downsizing initiatives, the success or failure of the contracting efforts has increasingly become dependent on the effectiveness of the related subcontracting. With that extensive subcontracting has come loss of control and often disappointing cost savings. The response of some companies has been to select their own subcontractors—which has resulted in cost savings, but also has created the necessity for increased contract monitoring. Whether or not one uses this new approach, several measures can be included in the contract to improve the likelihood that the outsourcing will be successful in terms of cost savings and task performance.

Over the past several years businesses have adopted a new management philosophy which asserts that the organization does not grow and prosper through acquisitions, but rather through partnering and networking. Part of this new mindset entails that the organization no longer needs direct line control over all of its components. Rather, components that are not part of the "core functionality" of the organization might be better performed by experts from those areas. This would reduce the overhead expenses of the organization, and improve the quality of the work product. This trend is similar to the trend in hardware manufacturing, where manufacturers no longer need to produce all the components of their products inhouse. Instead, they competitively procure components from outside the company to use in the manufacturing process.

As outsourcing has become more accepted, and more companies outsource whole functions, especially in the automatic data processing (ADP) area, subcontracting and how it is handled could have a significant impact on the success or

failure of the outsourcing effort. This concern came to light in a Deloitte and Touche study that included a survey of 1,500 chief information officers (CIOs) in the United States and Canada, which indicated that only 31 percent believed that their outsourcings generated significant cost savings, with 69 percent being disappointed in their outsourcing results ("Uneasy Pieces," 1997). This survey made two things apparent.

First, these executives believed that they would achieve savings through economies of scale or superior contractor resources. But these expectations did not materialize, because the fixed-price contracts they entered into did not subsequently pass along the hardware, software, or personnel savings over time. These experiences were also supported by Lacity and Hirschheim (1993), Lacity, Willcocks, and Fitzgerald (1996), and Scheier (1997), who found that commercial contracts dealing with outsourcings have experienced problems with long-term contracts similar to those previously mentioned. As such, the current trend has been to look at shorter time spans, so that changes in scope and productivity improvements can be reflected in the contract agreement; or, to frame the contract such that it is renegotiated at periodic intervals to adjust it to current market prices or changes in requirements.

Second, the executives also complained that vendors were not up front about the amount of subcontracting that would be used for the execution of their contracts. This became a problem when the subcontractor was unfamiliar with the contract provisions or customer expectations, and did not deliver the required services in the expected way. This concern was also voiced in an *Info World* article ("Managing Your Outsourcing," 1996), which described how many firms that had outsourced their information technology functions were starting to reduce the scope, or cancel parts of those efforts, because of lack of control over the vendors or subcontractors.

These results were similar to an earlier Gartner Group survey of 180 clients (1995), which found that only about 37 percent of information technology outsourcings were viewed as being successful, either through improved performance (21 percent), or cost savings (16 percent); while the remainder of the respondents indicated either a mixed or too-early-to-tell response. Recent Gartner Group surveys have continued to show that gains from outsourcing have consistently fallen short of expectations by CIO's ("Outsourcing to the Rescue," 1997). These surveys blamed the contracting process for not defining key issues and anticipated expectations. In the article, Gartner vice president Mike Vargo said customers also do not realize that an outsourcing relationship takes more time and effort than they anticipated.

Subcontracting as a Solution, Not a Problem

The above problems reflect what can happen when little thought is given to the outsourced function. In a perfect world, of course, it would be much easier to allow a prime contractor to manage the whole outsourced function, smoothing over difficulties and integrating the subcontractor's performance. However, the above study indicates that the prime

contractor may not always be good at performing those functions, or may not choose the least expensive approach.

The government might address these concerns in one of two ways. First, it can undertake its own selection of subcontractors, and subsequently monitor their performance, by contracting separately for each "subcontractor" function. Thus, it can convert what normally would be subcontractor functions (which cannot be monitored under the "privity of contract" principle) into regular contracted functions, which can be monitored and directed. Second, it can place detailed monitoring measures and baselining provisions in the contract.

Selecting your own subcontractors as a way to save additional money on outsourcing has recently become a popular avenue for those companies willing to take on the responsibility. This process is similar to becoming your own general contractor in building a house, where you interview and select the different trade people who will perform the various construction tasks.

Likewise, in information technology endeavors, multiple vendors are selected according to their areas of expertise. This was recently done by Halliburton Company, which found that specialized information technology vendors could provide optimal services for as much as 10 to 15 percent less than what a prime contractor would charge ("Outsourcing Megadeals," 1995). The company also reported that by breaking the outsourcing into pieces, it could see the value better by getting a clearer picture of where the vendor was making its investments and profits. Other companies that have followed this strategy are Aetna, Eastman Kodak, DuPont, Zale's, and J. P. Morgan; they all sought better service and more control over their information technology ("The New Outsourcing," 1996). Part of this trend of breaking out functions within an outsourced area originates from the recognition that a single contractor is usually not able to perform all the functions required, and, in turn, would have to subcontract some functions that were outside of its capability. An additional benefit of selecting your own subcontractor is that it allows for greater control over what is outsourced and what remains in house.

"Selecting your own subcontractors as a way to save additional money on outsourcing has recently become a popular avenue for those companies willing to take on the responsibility."

With the prospect of managing several subcontractors, some thought should be given as to how they will work together in functioning and dealing with one another; especially since some areas of responsibility will likely overlap. J. P. Morgan ("The New Outsourcing," 1996; and Bell Atlantic, 1997), in its outsourcing effort, specified a risk-reward contracting procedure that would provide positive and negative incentives for cooperation between the subcontractors. In this reward contract, savings achieved through better procedures and purchases would be put into a contingency pool, which would be shared between the company and the subcontractors. Likewise, if the subcontractors did not perform in accordance with the specified performance measurements, they would be penalized by some predetermined amount.

It should be said, though, that the selection and monitoring of subcontractors is a two-edged sword. While it affords the possibility of additional outsourcing savings, it may not come free either in terms of cost or time required to manage the effort. It could cost between 5 to 7 percent of the value of the contract to manage and oversee the subcontractors. That would cover renegotiating the contract agreements, resolving disputes, and tracking the contractor's performance (Scheier, 1996). These costs would vary depending upon the nature of the outsourcing, with the more flexible contracts requiring more contract oversight and subsequently a higher management cost. It should be pointed out, however, that these costs might be mitigated considerably if sufficient effort is spent on carefully defining in the contract how problems are to be resolved and how unexpected changes in requirements are to be addressed.

"It should be said, though, that the selection and monitoring of subcontractors is a two-edged sword."

Another concern that should be considered in the contracting process is the degree of specificity in what is outsourced, and what specifically the contractor is supposed to do. This is a fine line, for if the service levels are too tightly defined, the government could end up paying high fees for incremental projects outside the defined scope of the contract. For instance, companies have reported paying as much as 70 percent more than the original contract value for tasks outside of the defined scope of the contract (Lacity and Hirschhiem, 1993). Thus, there will be a tradeoff for the government, to make the contracts as flexible as possible to cover a broad range of needs and changing requirements, without overburdening them with too much contract oversight. Lacity and Hirschhiem further point out that outsourcing does not seem to work well in the following areas:

- where a specific or unique knowledge of the business is required;
- where all services are custom; or
- where the employee culture is too fragmented or hostile for the reorganization to come back together.

An additional consideration would be how the contract should be structured. For instance, the offeror's proposal should delineate what will happen to all of the existing assets under consideration: Which ones will the contractor assume responsibility for, which ones will remain with the government, and which if any will go to third parties? In addition, one should also consider if there are any intellectual property issues, such as software licenses (i.e., whether existing software can be transferred to the outsourcer), and ownership of self-developed software.

Finally, a significant consideration to improve one's chances of having a successful outsourcing effort concerns the use of detailed monitoring measures and baselining provisions that should be included in the contract. For instance, there are a number of measures that one can include in the contract to help determine if the contractor is meeting the goals and costs projected for the outsourcing

(Mylott, 1995; Rubin, 1997). These measures can be grouped together under the headings of performance criteria and comparability measurements.

Performance Criteria

These measurements are those that can be used to emphasize areas that are considered critical, or can aid in the customer satisfaction process, by informing the contractor what specific expectations exist for the effort. In addition, these measures should link specific operations to strategic goals. For instance, many performance measurements are still tied to the old concepts of standard accounting that were developed back in the 1920s; those measurements, however, no longer represent the current work environment (Lynch and Cross, 1991; Drucker, 1988). This problem has also been recognized by many accountants, for in a survey at a meeting of the National Association of Accountants and Computer Aided Manufacturing–International, 60 percent of the financial officers expressed dissatisfaction with their current performance measures (Howell, Brown, Soucy and Seed, 1987).

Performance measures that could be problematic are:

- **The purchase price**, which may not reflect quality and performance of the item;
- **Machine utilization**, which is subject to managers overrunning the machine to maximize utilization, which may not be warranted; and
- **Cost center reporting**, which is subject to managers focusing on centers and not activities, thus overlooking common activities.

Performance measures to consider are:

- **Response time.** Specify an average or specific response time for maintenance on critical equipment or software.
- **System availability.** Specify that particular hardware or software is functional on a daily, by shift, or by application basis.
- **Downtime.** Specify that particular hardware or software be down less than a particular amount of time, or require a particular mean-time-between-failure.
- **Turnaround time or schedule of performance.** Specify either a specific turnaround time on repairs, or a particular schedule of performance for equipment.
- **Performance reports.** Specify general performance criteria that are considered important to the outsourcing effort.
- **Penalties for nonperformance.** Penalties might also be used on some of the availability factors, to add emphasis for meeting the specific performance requirements.
- **Satisfactory performance statement.** State the organization's expectations of the vendor. These need to be clearly defined and discussed with the vendor.
- **Subcontractor approval rights.** Build these into the contract, to aid in

specifying what mission critical projects or systems are handled only by the primary vendor.

Comparability Measurements

For comparison, reports can be used to determine if the contract is relevant to similar costs for these services by other providers.

- **Operation's cost measures.** Specify that the contractor report cost in terms of CPU hours, storage costs, total cost per hour, fixed costs, or variable costs.

- **Communication's cost measures.** Specify that the contractor report cost per hour, by distance, per line, or per switch.

- **Service's cost measures.** Specify that the contractor report costs per person, or per application.

- **Value-based pricing and benchmarking.** Specify that the contractor periodically adjust the contract price to the "market price." An alternative to this would be to negotiate rates annually.

These measures should be reported on a monthly basis, and consist of a mix of both performance and comparability measures, which would be used to determine the monthly payment for the contractors. On the basis of their performance, the contractor may receive either an incentive fee for exceeding certain performance perimeter bands, or a penalty for falling below those bands. Scheier (1997) also suggests that cost measures should be broken out for specific items, rather than bundling large areas together, to make it easier to pinpoint which prices should be renegotiated.

Discussion

In general, outsourcing has become a very popular vehicle in the commercial sector, with more and more companies and now government entities obtaining services in this way (Washington, 1997). To maximize the possible savings and achieve the desired performance improvement, considerable forethought is necessary in structuring the contract, in monitoring the contractor's performance, and in the administration and oversight of the contract. One of the ways that additional savings could be achieved in the outsourcing area would be through the selection and monitoring of the subcontractors for specific areas of expertise. Care needs to be taken here, however, for there are both additional costs and time requirements associated with the process.

To mitigate some of the potential risks with outsourcings due to problems with the contracting process, a number of performance measures should be included in the contract to aid in meeting its goals for both performance and cost. These measures would then be used in the contract administration process to make sure that the contract is on track, and also, perhaps, to control contractor payments.

REFERENCES

Drucker, P. F. (1988, January-February). The coming of the new organization. *Harvard Business Review*.

Gartner Group Survey (research note). (1995, April 10).

Howell, R. A., Brown, J. D., Soucy, S. R., & Seed, A. H. (1987). Management accounting in the new manufacturing environment. Montvale, NJ: National Association of Accountants. (Cited in Lynch & Cross, 1991, p. 4.)

Lacity, M. C., & Hirschhiem, R. (1993). *Information systems outsourcing*. John Wiley & Sons.

Lacity, M. C., Willcocks, L., & Fitzgerald, G. (1996). *An empirical investigation of IT sourcing decisions: Lessons for best practice* (discussion paper). Oxford Institute of Information Management Research.

Lynch, R. L., & Cross, K. F., (1991). *Measure up: Yardsticks for continuous improvement*. Blackwell.

Managing your outsourcing (1996, September 9). *Info World*, 77-78.

Mylott, T. R. (1995). Computer outsourcing, managing the transfer of information systems. Prentice Hall.

The new outsourcing partnership (1996, June 24). *Information Week*, 585, 50.

Outsourcing megadeals. (1995, November 6). *Information Week*, 552, 34.

Outsourcing to the rescue. (1997, September 22). *Forbes Magazine 160*, 25–26.

Rubin, H. A. (1997, Spring). Using metrics for outsourcing oversight. *Information Systems Management*, 14, 7–15.

Scheier, R. L. (1996, August 19). Outsourcing's fine print. *Computerworld*, 70.

Scheier, R. L. (1997, July 21). Business outsourcing more but less thrilled with results. *Computerworld*, 14.

Uneasy pieces (No. 5, part 2, outsourcing; CIO White Paper). (1997, May 5). Available http://www.cio.com/.

Washington, W. N. (1997, July). *Outsourcing automatic data processing requirements and support* (research and development technical report, CECOM-TR-97-4, ADA327808). Fort Monmouth, NJ: U.S. Army Communications Electronics Command.

William N. Washington is an operations research analyst for the Directorate of Resource Management, HQ CECOM, Fort Monmouth, NJ. He has a B.S. degree from Kansas State University and an M.S. degree from Trinity University. His doctoral studies were in measurement, evaluation and research design at Michigan State University. He is a graduate of the Army Acquisition Corps Senior Service College (1995), and APMC (96-2). He has received the Secretary of the Army's Award for Outstanding Achievement in Material Acquisition (1994), a DoD Award for best paper at the 31st DoD Cost Analysis Symposium (1998), the Assistant Secretary of the Army (FM&C) Author of the Year Award (1997), and the Army Material Command's Cost Analysis Award for Modeling (1988). A member of the Army Acquisition Corps since its inception, he is rated Level III in career fields A, K & S.

(E-mail address: washinwn@mail1.monmouth.army.mil)

REENGINEERING THE ACQUISITION PROCESS: *A QUANTITATIVE EXAMPLE OF ACQUISITION REFORM WORKING FOR THE AIR FORCE'S LAUNCH PROGRAMS SYSTEM PROGRAM OFFICE*

Robert Graham and Capt Eric Hoffman, USAF

The objective of the Air Force's Launch Programs System Program Office (SPO) was to develop and improve the acquisition process. Realizing that the cycle time for contract proposals was an area that needed reform, the Launch Programs SPO set out to reengineer the process. By developing a contractor and government integrated product team that worked together to define a new streamlined approach for making changes to existing contracts, the Launch Programs SPO has quantitatively demonstrated an average 63 percent cycle time reduction.

The mission of the Air Force's Launch Programs System Program Office (SPO) at Los Angeles Air Force Base, CA, which oversees the Titan, Delta, and Atlas launch vehicles, and the Centaur and Inertial Upper Stage boosters, is to acquire and sustain a reliable, affordable national space launch capability. Launch Programs is facing the challenges common to the Department of Defense (DoD):

The views expressed here are those of the authors and do not necessarily reflect those of the Air Force or Launch Programs SPO.

downsizing, turnover, and competition. To meet the goals outlined in the National Performance Review and Air Force Lightning Bolts, the Launch Programs system program office at the Air Force's Space and Missile Systems Center launched its own aggressive business process reengineering initiative to design and implement an improved and streamlined contract change process (CCP). The specific goals of the reengineering initiative were to streamline the contract change process; reduce process cycle time by at least 50 percent; and implement a comprehensive training program. To achieve those goals, the organization emphasized teamwork, accountability, project management, and empowerment.

"In the past, making modifications to contracts has been a long, tedious process..."

In the past, making modifications to contracts has been a long, tedious process; it is a problem that pervades every part of the government procurement system. The traditional process by which one puts an engineering change proposal (ECP) on contract has six broad areas, in which decisions, roles and responsibilities, and processes are conducted in a bureaucratic environment. First, the project officer develops a requirement without contractor input (Category 1: Requirement Development). The contracting officer develops and issues a request for proposal (RFP) in a vacuum, without contractor participation (Category 2: RFP Development). It is then the contractor's responsibility to understand and interpret the government's requirement and propose a meaningful solution that is acceptable to the government. The contractor accomplishes this without government assistance or insight (Category 3: Proposal Development). The result is numerous revised proposals and technical meetings to understand the government's requirements.

During the proposal review, the requirement is eventually defined and the contractor gains full knowledge of the government's requirement (Category 4: Proposal Review). Negotiations are usually adversarial (Category 5: Negotiations). Finally comes the time-consuming process of awarding the contract modification, with numerous burdensome regulations (Category 6: Contract Award). Everyone has agreed that this process is broken, but for Launch Programs, it was not until the introduction of the reengineered contract change process that the traditional process was eliminated and an integrated product team (IPT) developed a streamlined method for accomplishing a contract modification.

Several years ago the Delta II Launch Vehicle IPT assembled a team that proposed the innovative process now used by Launch Programs. The process basically "front-loads" a large portion of the work that used to be completed after the contractor submitted its proposal. The new process forces the government to work with the contractor as a team to develop the requirement for a contract change. The teamwork continues during the request for proposal (RFP) and proposal development process, and the team actually reaches consensus on the hours and materials required to complete the project before the proposal is submitted to the government. Thus, once the proposal is actually submitted to the government, it is known exactly what it will contain, and ultimately

the government dramatically reduces the turnaround time for putting an ECP on contract.

The Reengineered Contract Change Process

The contract change process that reduced cycle time for the Launch Programs system program office is organized into six stages: need validation; solution definition; proposal request, preparation, and review; proposal disposition; contract modification completion; and contract modification signature and distribution (Figure 1). The purpose and description of each stage is provided below, as well as the improvements gained through the reengineering effort.

Stage 1: Need Validation

The purpose of Stage 1 is to ensure that needs are validated as requirements using a defined, rigorous process based on program office priorities. This stage brings much greater discipline into the acquisition process (the reengineering team had found that previously there was no measurement of when or how a need was validated and became a requirement). By formalizing the process, senior management is aware of the need and the justification for the validation of that need. Each need is identified and evaluated using established criteria, then validated as a requirement by the affected program manager. The benefits of the need validation stage are that the new process provides structure and discipline to the formerly vague requirements validation process. It requires project officers to clearly define potential requirements and encourages the program manager to filter out extraneous changes.

Stage 2: Solution Definition

The purpose of Stage 2 is to identify the best solution based on the impact on technical capability, sustainability, cost, schedule, and risk to the program. Under this stage, the project team is formed and reviews the requirement, evaluates alternative solutions, and provides a recommended solution, which it then presents to the solution validation board in the form of a solution validation briefing. The team also develops a project schedule and begins preparing documentation, such as the statement of work (SOW), and draft Request For Proposal (RFP). The project team consists, at a minimum, of the project officer, buyer, budget analyst, contractor, and end military user. Depending on the scope and complexity of the project, the team may also include representatives from Configuration Management, Defense Contract Management Command (DCMC), Defense Contract Audit Agency (DCAA), legal counsel, and other agencies as necessary at this stage of the process.

"The contract change process that reduced cycle time for the Launch Programs system program office is organized into six stages..."

The benefits of this stage result from the combined expertise of the project team developing a coordinated, well-defined, and understood solution that best meets mission needs and prevents ambiguity in either the technical or contractual requirements. Establishing a project schedule early in the change process also keeps the

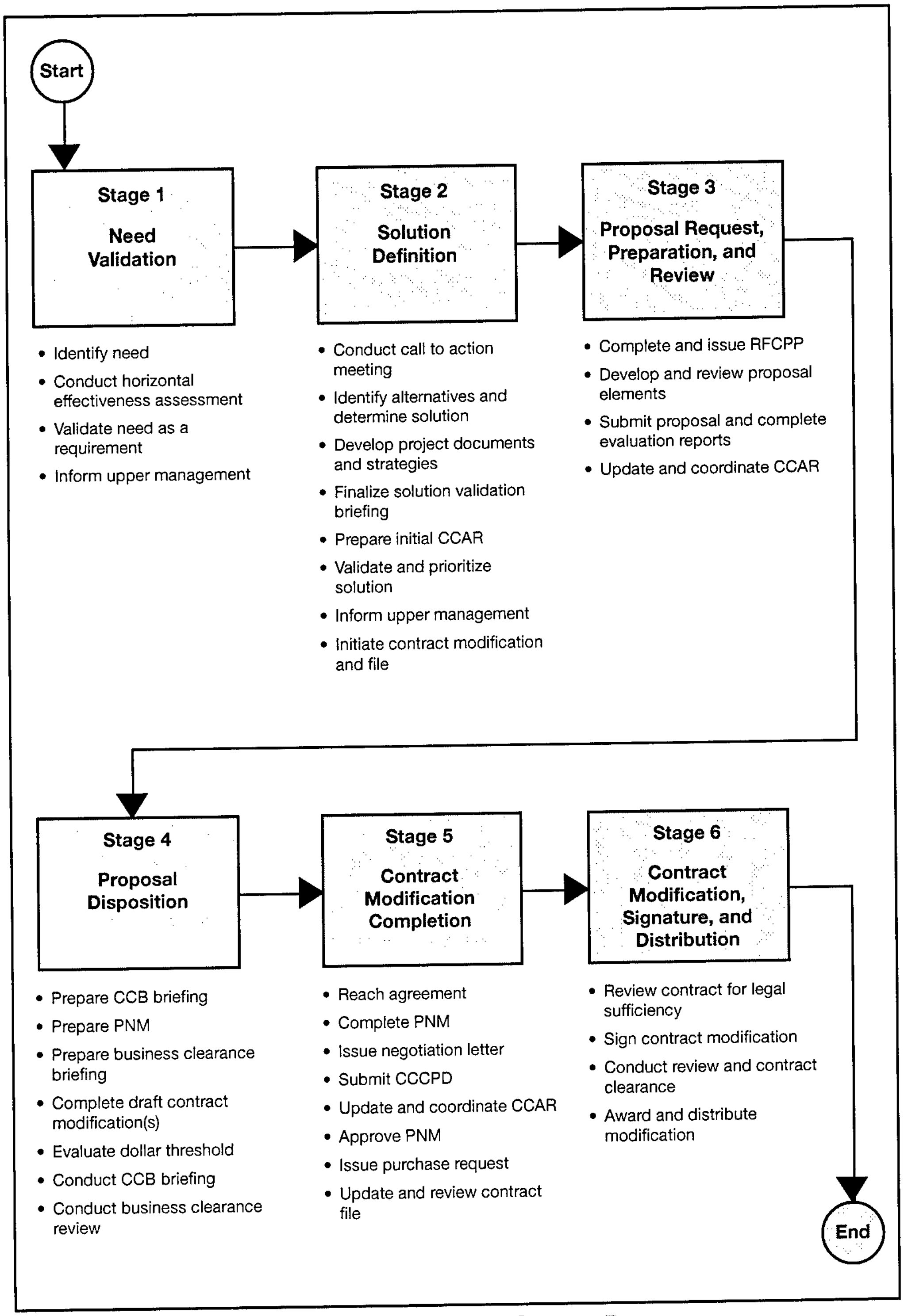


Figure 1. The Contract Change Process

team focused and helps avoid "lagging" requirements. Finally, communication of the requirement to stakeholders in the acquisition process allows the team members to prepare for and address potential budget, contracting, legal, or other issues immediately.

Stage 3: Proposal Request, Preparation, and Review

The purpose of Stage 3 is to issue the RFP, develop and incrementally review the technical and cost elements of the proposal with the prime contractor, and submit the final proposal. This stage is the most significant because it brings the government acquisition process closer to commercialization by working together with the contractor to develop a proposal. The 60-day waiting period, during which the contractor develops a proposal based on the RFP, is eliminated. The contractor does not work in a vacuum to develop his proposal but works with the government engineers to establish the labor skills and mixes and hours for the proposal. The contractor also works with the DCMC and DCAA on material and rates and factors for the proposal. Under this stage, a preliminary agreement is reached between the parties on the proposal before it is submitted: all are in agreement prior to submittal of the contractor's proposal.

As mentioned above, the project team issues the RFP, then works with the contractor to review the proposal incrementally as it is being developed. The proposal development process for Stage 3 has three reviews. The reviews are similar to a 30 percent, 60 percent, and 90 percent review done during certain types of acceptance testing. The initial review (when 30 percent of the estimated effort is completed for the proposal) ensures that the contractor understands the technical requirement and solution. The contractor then develops labor and material estimates. The majority of concurrent fact-finding is done in the middle review (when 60 percent of the estimated effort for the proposal is complete), in which the project team, including the contractor, reviews the contractor's basis of estimates (BOEs) to achieve consensus on labor hours, engineering category and skill level, materials, and subcontractor effort. The team reviews the BOEs to achieve consensus on all issues. The middle review is critical because at this stage of the process the team resolves the majority of the issues. Between the middle and final reviews, the team will resolve any remaining open issues. The final review (when 90 percent of the estimated effort for the proposal is complete) is to resolve any outstanding issues prior to proposal submittal.

"This stage (3) is the most significant because it brings the government acquisition process closer to commercialization by working together with the contractor to develop a proposal."

Representatives from DCMC and DCAA also support reviews of the proposals over the $500,000 threshold, and begin the price analysis report and audit at this time. The audit is done incrementally and the final report is not the traditional thick package that the DCAA usually issues. For this process, the DCMC comes to an understanding with the contractor on the kinds and quantities of material before the proposal is submitted to the government. The auditor then issues

a memorandum to the buyer stating that he is in agreement with the kinds and quantities of material to be presented in the resulting proposal. By using this process, Launch Programs has eliminated the classic audit report and lead times associated with the submittal of an audit report.

Once consensus is achieved, the contractor submits the final proposal, which is then accepted as written by the government—another significant idea implemented by Launch Programs. In order to accept the proposal as submitted, the contractor must submit the proposal in accordance with the consensus building and audit agreements, and in accordance with the established memorandum of agreement (MOA) between the organizations.

"The MOA is an intergovernmental and quasi-organizational agreement between the DCMC, DCAA, the contractor, and the program office on the acquisition process."

The MOA is an intergovernmental and quasi-organizational agreement between the DCMC, DCAA, the contractor, and the program office on the acquisition process. It details the acquisition process, each organization's responsibilities to the acquisition process, and a rate agreement between the parties. The MOA is the road map for the reengineered process. The MOA is similar to a team charter. There is also a section in the MOA that discusses rates and factors. This section details the process when there are forward pricing rate agreements (FPRAs) and what must be accomplished in the case when there are no FPRAs. Profit rates are not specifically addressed in the MOA. What is agreed to between the parties in the MOA are the rates and factors that are entered in the DoD Form 1861 (weighted guidelines form). The MOA conforms to all acquisition regulations and is an innovative approach to resolving the rate and factor, and profit differences that usually occur between the parties. Therefore, if you have agreement on labor hours and material, and agreement on the rates and factors for labor and overheads, and agreement on rates and factors for determining profit, then when the contractor submits the proposal in accordance with these agreements, the government can accept the proposal as submitted by the contractor.

The benefits of this stage show that the team achieves consensus on the technical, cost, and contractual elements of the contractor's proposal through teamwork, understanding, and communication during the proposal preparation process. Without the openness and teamwork of working for the common good of both organizations, the incremental review of the proposal would not be a productive activity. The key to consensus building is understanding and communication of the proposal and the requirements, so that everyone understands the logical way to proceed to satisfy the requirements. By working together on the proposal, quality is built in so there are no costly revisions or fact-finding to understand the requirements or meaning of the proposal. The contractor's final proposal is then accepted as written, avoiding numerous revisions and added cycle time.

Stage 4: Proposal Disposition

The purpose of Stage 4 is to prepare for and conduct the configuration control board (CCB) and business clearance. In

this stage, the project officer leads the team in concurrent preparation of the price negotiation memorandum (PNM), CCB briefing package, and business clearance briefing. This step combines both briefings. The benefit of combining CCB and business clearance eliminates another coordination step in the contract change process, saving time and using existing forums most efficiently.

Stage 5: Contract Modification Completion

Stage 5 is to ensure that a final agreement has been reached between the contractor and the project team, and to put that agreement is in writing. Once the proposal has been approved through CCB and business clearance, the contractor and buyer confirm the agreement and the contractor forwards the confirmation of negotiations letter and certification of current cost or pricing data (CCCPD).

The benefits from this stage show there are few changes required because the majority of the effort and coordination has been completed in earlier stages. Traditional protracted negotiations are noticeably absent.

Stage 6: Contract Modification Signature and Distribution

The purpose of Stage 6 is to review the contract modification for legal sufficiency and compliance with policies and regulations, and to ensure that the modification file is complete and accurate. In this stage the contract clearance authority obtains the contractor's signature on the modification, and the procuring contracting officer awards the modification. The buyer then distributes the completed modification to the affected parties. There are few changes in this stage of the process, which contributes to streamlining efforts. It should be noted that coordination earlier in the process would expedite processing of the modification.

The benefits of this stage show that having the legal office review the modification file for legal sufficiency prior to obtaining contractor's signature saves valuable transmittal time in the event the lawyer finds a discrepancy. Furthermore, the legal office has already been engaged during Stage 3 (proposal preparation), and coordinated on any special contract provisions or other legally sensitive issues to make this final review pro forma. Distribution of the modification has not changed under this process. The contract change process is complete and ends after this activity.

"The objective of the Launch Programs SPO was to develop and improve the acquisition process."

Validation of Launch Program's Reengineering Goals

The reengineered process defined specific improvement areas targeted by the Launch Programs SPO director. The goal of the SPO was to make business management a part of Launch Programs culture.

The objective of the Launch Programs SPO was to develop and improve the acquisition process. The reengineered process has improved the cycle times of the acquisition process; the following analysis validates the results of using this streamlined method.

Launch Programs correctly anticipated the need for more control in the requirements process, and enhanced controls were put in place in the reengineered process. These new controls reduced upfront cycle times for the contract change process.

The objectives of the reengineering effort were achieved and implemented throughout the Launch Programs SPO. The acquisition process was streamlined and it has reduced process cycle times. The following analysis will look at the achievements of the Launch Programs SPO using a program evaluation review technique (PERT) analysis to validate the hypothesis.

"The acquisition process was streamlined and it has reduced process cycle times."

Hypothesis

This process has been used since 1995 in the Delta II IPT, when it was initially proposed to reduce cycle times by 50 percent. The hypothesis for this analysis is whether the contract change process reduces cycle times by 50 percent or more. The antithesis is that the contract change process does not reduce cycle times by at least 50 percent.

To test this hypothesis, a PERT analysis was used to determine the critical path and average length of time to complete engineering change proposals using the traditional and reengineered process, and to determine the average cycle time reduction that the reengineered process has actually achieved.

The Delta II IPT processes five to seven ECPs per year. A random sample of five ECPs that were completed with the traditional process and five ECPs that were completed using the new reengineered process were chosen for this analysis. A government tracking system (acquisition management information system [AMIS]) was used to track the progress of each ECP. A copy of the AMIS tracking form is included in each ECP file. The AMIS tracking forms used in this analysis are included in the Appendix. The printouts list very specifically the various milestones that must be completed for each ECP. Since AMIS uses the traditional government tracking system, there is a variance between milestones in the two processes. The milestones used for this analysis are:

- *Requirement identified (RI).* This is the date the government identified the need for a change to an existing contract. This date is the same for both processes.
- *Acquisition strategy panel completion (ST).* This is the activity that determines whether the change is in scope or out of scope to the existing contract. For the reengineered process this is the date of the completion of Stage 2.
- *Solicitation issued (SI).* This is the date when the government requests a proposal from the contractor (request for proposal, RFP). This date is the same for both processes.
- *Proposal/bids received (PR).* On this date the contractor submits the proposal to the government. This date is the same for both processes.

- *Price evaluation/technical evaluation/ audit completion (PT).* This is the date (the same for both processes) when all three of these activities have been completed by government personnel.

- *Negotiations completion(NC).* The date negotiations are complete between the parties. Under the reengineered process this is the date of final consensus under Stage 3.

- *Contract file completion (CF).* This is the date when the file is complete and ready for management review. This date is the same for both processes.

- *Contract writing completion(CW).* On this date (the same for both processes) the file has been reviewed and is ready for the contractor's signature.

- *Contractor signed (KS).* This date, the same for both processes, is when the contractor signed the ECP.

- *Legal review completion (JR).* This is the final review of the modification by a government contracts lawyer for legal sufficiency. This is required for modifications over $500,000. This date is the same for both processes.

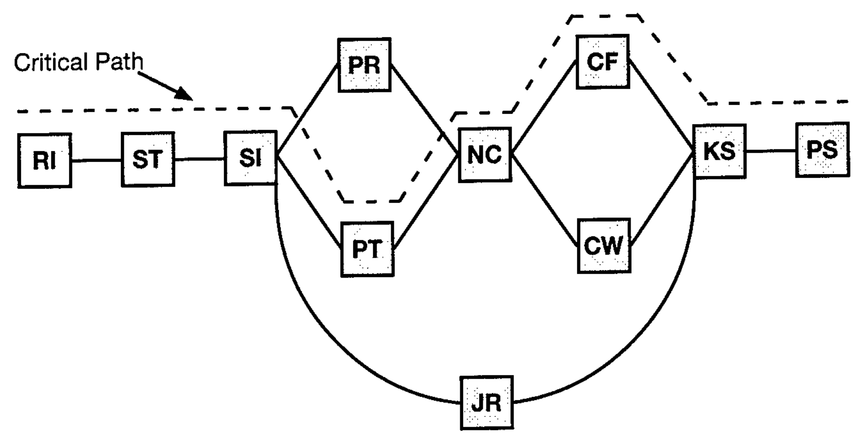
- *Procurement contracting officer signed (PS).* This date, the same for both processes, is when the contracting officer for the government approved the change and obligated the money.

On the AMIS tracking form (see Appendix A), next to each milestone is the scheduled, forecast, and actual date that the milestone was completed for the ECP. The actual date is the one used to calculate the amount of time it took to complete each task. All the dates from the AMIS tracking forms were converted into numerical data (how many weeks it took to complete each activity) and recorded on a spreadsheet (Appendix B). The result was a spreadsheet that calculated the time for each activity per ECP, the total time per ECP, and the average time to complete each of the five ECPs.

The spreadsheet was further expanded by performing the PERT analysis as described in *Quantitative Approaches to Management* (Levine, Rubin, Stinson, and Gardner, 1992). Spreadsheet Column T(1) is the streamlined approach, Column T(2) is the average time for ECPs, and Column T(3) is the worst case for each activity. From these T values it is possible to calculate the expected time and the standard deviation for each task.

"The result was a spreadsheet that calculated the time for each activity per ECP, the total time per ECP, and the average time to complete each of the five ECPs."

The next step of the PERT analysis was to make a "forward pass" through the network to determine the earliest start and finish times for each activity. A "backward pass" was then completed through the network to find the latest start and finish times for each activity. By comparing these passes through the network, the amount of slack time for each activity can be determined. Any activities that have no slack time are on the critical path. The network diagrams for each process were drawn using the Activity-on-the-Node (A-O-N) method (Figure 2).



	Key
RI	requirement identified.
ST	acquisition strategy panel completion.
SI	solicitation issued.
PR	proposals/bids received.
PT	price evaluation/technical evaluation/audit completion.
NC	negotiations completion.
CF	contract file completion.
CW	contract writing completion.
KS	contractor signed.
JR	legal review completion.
PS	procuring contracting officer signed.

Figure 2. The Old ECP Process

The variances for the system deal with the following observations about the AMIS tracking form: various activities occur in a serial fashion on the form; however, there are several areas in the process where work can be completed in parallel. Any time an activity was completed on the same day as the preceding activity, a time of zero was entered for time of completion of that activity. The serial nature of events on the AMIS tracking form only considers the traditional acquisition process, but there were several activities under the reengineered process that occurred out of the traditional sequences. These variations were observed in this analysis and considered in the findings presented for the reduction in cycle time.

It should also be noted that there are no times listed for "requirements identified," as this is the starting point of the network and by default it is on the critical path. The AMIS form tracks the contracting activities from this point. For RI there is no validated starting point and in our research we could not find any cycle times related to the beginning of any procurement activity in the traditional acquisition process studied for this paper. In the

reengineered process, in theory, you can track the RI time from the beginning of the Stage 1 briefing to the conclusion of the Stage 2 briefing as the RI time for the reengineered process. Since the reengineered process is not adapted to AMIS, there is no data for the specific stages in the reengineering process. Therefore, this analysis is constrained by the traditional process of project scheduling for ECPs.

CRITICAL PATHS

TRADITIONAL PROCESS

The activities necessary to complete ECPs using the traditional acquisition process were more serialized and required more milestones to be completed before awarding a modification. The serial process resulted in much higher average cycle times. The average cycle time under the traditional process was 46.5 weeks for an ECP with an average value of $700,000. Table 1 below shows the results of the PERT analysis (Appendix B).

The numerical analysis for the traditional process found two activities on the critical path that took a very long time to complete. The PT and NC activities took approximately 11 weeks and 12 weeks to complete, respectively. These two activities combined took more time to complete than the average engineering change proposal under the reengineered process.

It is also important to note that several of the activities had a high standard deviation associated with the degree of uncertainty in the calculated expected time to completion values. The high standard deviations reflect the spread of the low and high values in the columns T(1) and T(3).

The lack of consistency, lack of teamwork, and the potential adversarial relationships in the traditional process may lead to the large difference between the expected and required time to complete some activities. The unquantifiable

Table 1. Results of PERT Analysis of Old ECP Process[a]

Activity	Average Time	Expected Time	Standard Deviation	Slack Time	Critical Path?
RI	—	—	—	—	Y
ST	3.51	5.1	2.76	0.0	Y
SI	0.83	1.1	0.52	0.0	Y
PR	6.46	7.0	1.31	4.0	
PT	11.11	11.0	3.31	0.0	Y
NC	12.31	12.2	1.76	0.0	Y
CF	3.51	3.7	0.98	0.0	Y
CW	0.26	0.3	0.12	3.4	
KS	1.09	1.3	0.50	0.0	Y
JR	7.20	9.9	4.69	17.0	
PS	0.20	0.2	0.07	0.0	Y
Total time	46.48				
Value (dollars)	690,484				

[a] All times in weeks.

relationships between the parties directly affect the quantitative analysis of the critical path and leads one to believe that a better relationship may reduce cycle times. Since this cannot be rationally defined in numerical terms, the analysis drew a conclusion from existing evidence that external factors may affect the standard deviation.

Reengineered Process

The reengineered process reveals that it requires more of the work to be completed up front and many of the milestones can be completed by working activities in parallel. It can be concluded that the ability to work activities in parallel and front-loading the process adds value to the reengineered process and reduces the average cycle times. The average time to complete an ECP under the reengineered process was 17 weeks. The average value of the ECPs that participated in the reengineered process was $4.4 million. This reduction in cycle time represents, approximately, a 63 percent reduction in time required to complete ECPs. It also demonstrates that high-value ECPs can be processed quickly and efficiently in the reengineered process. The ECPs analyzed for the reengineered process are on average 6.5 times greater in value than those ECPs analyzed in the traditional process. This is important to note because typically the larger the value of the ECP, the greater the amount of review it receives in the process. Without looking at an equally high-value ECP in the traditional process it is hard to conclude that the higher value ECPs impact the analysis. What this may show is that regardless of ECP value, the reengineered process streamlines the contract change process.

The numerical analysis of the reengineered process network diagram reveals that there is one specific task on the critical path that took a long time to complete (Table 2). The SI activity took an average

Table 2. Results of PERT Analysis of New ECP Process[a]

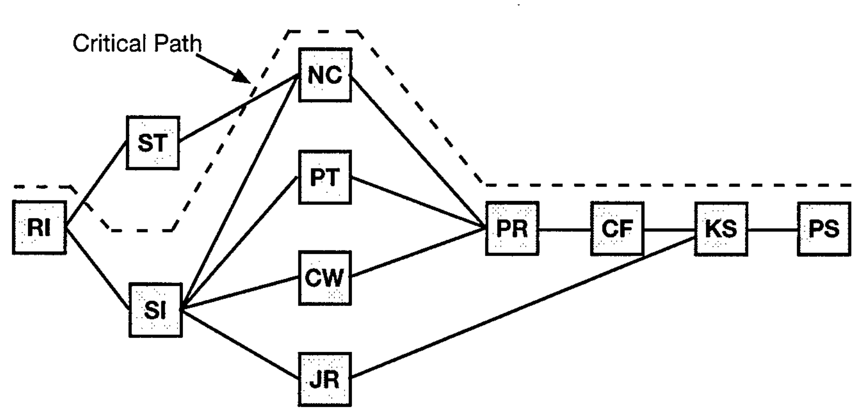
Activity	Average Time	Expected Time	Standard Deviation	Slack Time	Critical Path?
RI	—	—	—	—	Y
ST	2.03	2.8	1.43	8.2	
SI	10.03	11.0	4.21	0.0	Y
PR	1.86	1.8	0.45	0.0	Y
PT	0.57	0.6	0.22	0.2	
NC	0.69	0.8	0.31	0.0	Y
CF	0.66	0.7	0.24	0.0	Y
CW	0.14	0.2	0.12	0.6	
KS	0.57	0.8	0.38	0.0	Y
JR	0.31	0.5	0.07	2.8	
PS	0.26	0.2	0.07	0.0	Y
Total time	17.12				
Value (dollars)	4,443,192				

[a] All times in weeks.

of 10 weeks to complete with the reengineered process. Further analysis shows that one ECP may be the cause for this long cycle time. The SI activity for ECP number 3 required 25 weeks to complete. This ECP was delayed due to higher priority contract actions and may not be representative of the true streamlining abilities of the reengineering process. Examination of the raw data indicates that after work was resumed on the ECP it was completed within normal cycle times for the remaining activities in the reengineered process.

It is also important to note that several of the new process activities had a high standard deviation associated with the degree of uncertainty in the calculated expected time to completion values. The high standard deviations reflect the spread of the low and high values in the columns T(1) and T(3) (Appendix B). The long acquisition strategy panel completion activity of more than 8 weeks for ECP number 3 caused the high standard deviation for that activity. There were scope issues that delayed the change from progressing within the streamlined parameters. The long SI activity for ECP number 3 also contributed to the high standard deviation in the reengineered process for this activity.

From the analysis of the new process (Figure 3) it can be seen that external factors also influence the progression of cycle



Key	
RI	requirement identified.
ST	acquisition strategy panel completion.
SI	solicitation issued.
PR	proposals/bids received.
PT	price evaluation/technical evaluation/audit completion.
NC	negotiations completion.
CF	contract file completion.
CW	contract writing completion.
KS	contractor signed.
JR	legal review completion.
PS	procuring contracting officer signed.

Figure 3. The New ECP Process

times. These real world examples show that regardless of the best efforts on the part of the Delta II IPT to streamline the contract change process, there is a range of values that can be considered acceptable for meeting cycle times. Prior to this analysis, these values were theoretical to the program office and it was not until this PERT analysis of cycle times was completed that these theoretical cycle time limits could be adopted as being within an acceptable range for the Launch Programs SPO's goal to reduce cycle times. This PERT analysis was also very useful because it was able to quantify an actual cycle time reduction of the reengineered process.

"...we have determined that the activity that takes the longest amount of time to complete under the reengineered process is the issuance of the solicitation."

CONCLUSIONS

The PERT analysis illustrates three important points about the reengineering process. First, the 63 percent reduction in cycle times actually exceeds the initial goals set forth by the reengineering process team. The PERT analysis verifies the results of reengineering and proves that the new process contributes greatly to the efficiency of the acquisition process. The significant reduction in cycle time also verifies that the reengineered process is not the traditional process reordered to be more effective.

The analysis also provides insight into the formal identification of the critical path for each process. The identification of the critical path for the traditional process was important as a comparative study on how reengineering was not constrained by the traditional critical path for cycle time improvements. Understanding the critical paths was significant in streamlining the acquisition process, and understanding the comparative basis of each process is instructive for the cultural change required within the program office.

The final point derived from the analysis is the value of quantifying the activity time on the critical path for examination of the improvements by activities rather than at the aggregate level. This analysis justifies the continued use of the reengineering process for Launch Programs and other acquisition organizations.

As a result, we have determined that the activity that takes the longest amount of time to complete under the reengineered process is the issuance of the solicitation. Consequently, management should focus on this activity to achieve further improvement. This is within the control of the government. The other activity that requires management attention, receiving a proposal from the contractor, is not within the government's control; therefore it is incumbent upon contractors to take the initiative to streamline their own internal processes to compliment the government processes in streamlining the acquisition process.

The comparative analysis also found that the activities that take the longest in each process are different. One would think that by applying efficiencies to the traditional process one would be streamlining the contract change process and thereby meeting cycle time goals. This was not the case. The traditional process

has PT and NC as its longest activities. The goal of the reengineered process was to front-load the process to end the lengthy technical evaluation and negotiation phases. This was achieved, but it seems that efficiencies were lost in SI and PR activities under the reengineered process. Again, this can be explained by the front-loading structure of the process. By working with the contractor up front to have a proposal that can be accepted as submitted to eliminate traditional negotiations, the consensus-building process extended the cycle time to compensate for such efficiency.

If you discard the traditional process and work within the reengineering process, the spreadsheet Column T(1) (Appendix B) times are being met in most cases, and therefore the comparison is not equivalent to improving the efficiencies of the traditional process. The goal of reengineering is to make organizations "think out of the box" and discard the traditional process for the new reengineered process. This is what the Launch Programs SPO accepted in streamlining the acquisition process.

The two keys to consistently implementing the reengineering process over many programs are teamwork and consensus building. A team methodology better defines and validates the need as a requirement. It brings structure up front in the process and allows for better communication between organizations.

Consensus building combines proposal building and evaluation to obtain consensus prior to the formal submission of the proposal. The incremental reviews allow the team to work out problems and reach a common understanding of the work being performed and the tasks needed to complete the effort. Launch Programs has also made improvements in the CCB and business clearance subprocesses to complement changes in the requirements definition and contract consensus subprocesses. Finally, the acquisition process has been standardized over all Launch Program IPTs to shorten the acquisition process in duration and increase workplace efficiency.

"The two keys to consistently implementing the reengineering process over many programs are teamwork and consensus building."

The results of the PERT analysis show the critical path necessary to streamline the acquisition process. The analysis identifies activities with long cycle times to management and thus shows which activities require attention. Finally, the analysis validates the hypothesis that the reengineering process has reduced cycle times by at least 50 percent. The findings indicate that cycle times have been reduced by an average of 63 percent and with added efficiencies it is believed that Launch Programs could achieve a 70 percent cycle-time reduction.

Lessons Learned

The analysis laid out here shows that:

- It is important to empower people at lower levels.
- It is vital to remove unnecessary and non-value-added policies, rules, and regulations.
- Development of a low value checks and balances system streamlines cycle times.

The need to empower people at lower levels is critical in today's downsizing environment. The reengineered IPT recognized this tenet and successfully integrated it into the process. The process empowered people at lower levels by giving the project officer the responsibility for the process. He or she is empowered to define the requirements, gain acceptance of the requirements from senior management, agree to labor and material, and gain approval for the contract change. The working-level IPT is empowered to seek agreement on terms and conditions.

"The need to empower people at lower levels is critical in today's downsizing environment."

Another valuable lesson is the importance of removing non-value-added policies, rules, and regulations. While the reengineered process sought deviations, review by senior management interpreted the critical ideas of:

- only one price negotiation memorandum;
- one clearance review approval;
- negotiated rates and factors for profit guidelines; and
- building consensus without the authority to negotiate, as legally sufficient and within the intent of existing regulatory and statutory requirements.

The reengineered process has benefited from acquisition reform and allowed the visionaries in the government to implement reforms with positive and innovative results.

The final lesson learned from the analysis is that in order to streamline the acquisition process, there must be a low-value check and balance system. The reengineered process initiated a "validation of the requirement" briefing to adequately define the requirement for the program. Another check was the single clearance approval briefing prior to pursuing contract award. This review is similar to an "end of runway check," to review that everything is in order and makes sense before approving the change and issuing a modification. This is the contract approval authority's final check before the requirement is incorporated into the contract. Other low-level checks and balances include the contractor's participation in the CCB briefing, contractor's participation in the RFP review process, the government's participation in the contractor's proposal review process, and the IPT's systematic reviews to ensure consistency and completeness to the process. These checks and balances were lacking in the traditional process, which sought one definitive briefing for each step. The key use of teamwork is an invaluable asset to the reengineering process when developing the necessary checks and balances to streamline cycle times.

In terms of program effort to accomplish a contract modification, additional program effort was saved by the fact that the reengineered process focuses on quality, the first time, for deliverables. This first-time quality effort for the RFP and proposal eliminates revised RFPs to the contractor and costly proposal revisions. Defining the requirement in the IPT and

the single focus on a firm requirement allows all participants to fully understand the scope of the acquisition. This saves effort in costly reinterpretation of the request for a proposal and rewrites of contract documents. The program office and the contractor agree to the requirements and the solution. The IPT is then tasked to complete a contract modification to implement the solution. There is a significant amount of effort saved when there is a firm requirement. The reengineered process has saved the program additional effort and added value to the overall acquisition process through these lessons learned by the Delta II IPT.

The reengineered process is a success—but this success is not without risks. One risk—possible perceptions of increased profit to the contractor from agreed-to rates in the memorandum of agreement—was mitigated by the fact that the reverse actually occurred. The contractor needed to hold many briefings with corporate authorities to show the process benefits. Another perceived risk is the concept of empowering people at the lowest level to make decisions for the program. However, the delegation of responsibility is a necessity with the downsizing of government and this risk is mitigated by the formal briefings given to approval authorities.

In today's downsizing and increasingly competitive environment, both inside and outside the government, these projects highlight the significant accomplishments of individuals and organizations, and their commitment to acquisition reform and the idea of doing business faster, cheaper, and better.

Robert Graham is a senior contract negotiator with the Delta II Launch Program Office at Los Angeles Air Force Base, and is a Certified Professional Contracts Manager (CPCM) with the Air Force. He received a bachelor's degree from Whittier College and a master's degree in public administration from the University of Southern California. He is a graduate of the Air Command and Staff College and the Naval War College. Previous experience includes positions in Air Force Launch Programs, the Navy's Space and Naval Warfare Systems Command, and China Lake Naval Warfare Center. (E-mail address: RobertG.Graham@losangeles.af.mil)

Capt Eric Hoffman, U.S. Air Force, earned a B.S. degree in aeronautical engineering from Embry-Riddle Aeronautical University and an MBA degree from Pepperdine University. In his six-year acquisition career, Hoffman has worked as a systems engineer on the Pegasus launch vehicle; a propulsion and ground systems engineer in the Delta II Launch Vehicle Program Office; and is currently the MILSTAR on-orbit operations manager in the Military Satellite Communications (MILSATCOM) Joint Program Office. (E-mail address: Eric.Hoffman@losangeles.af.mil)

REFERENCE

Levine, R., Rubin, D., Stinson, J., & Gardner, E. Jr. (1992). *Quantitative approaches to management* (8th ed., p. 31). New York: McGraw-Hill.

Appendix A

AMIS Tracking Forms

ECP #1

** PMS BUYING PLAN REPORT FOR **

95SEP21 OWNED BY: SMC 14:17

PURCH-DESC: 3RD STAGE CONTROL BOX					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$800,029	EST-TOT-AMOUNT: $800,029		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		94OCT11	AGE:	345	CWAM AGE: 337
NETWORK:	M4		SCHEDULED-TIME: 89		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	94OCT12	95FEB28	94OCT12
ST	ACQ STRATEGY PANEL COMP	94OCT19	95MAR07	94OCT19
SI	SOLICITATION ISSUED	95MAR14	95MAR14	94NOV10
PR	PROPOSALS/BIDS RECEIVED	95MAR23	95MAR23	94DEC09
PT	PRICE ANAL/TECH EVAL/AUDT	95MAY19	95MAY19	95FEB21
NC	NEGOTIATIONS COMPLETED	95MAY23	95MAY23	95MAY31
CF	CONTRACT FILE COMPLETED	95MAY24	95JUL15	95JUL20
CW	CONTRACT WRITING COMPLETE	95MAY23	95JUL14	95JUL24
KS	CONTRACTOR SIGNED	95MAY29	95JUL20	95AUG15
JR	JAG REVIEW COMPLETED	95MAY26	95JUL17	95SEP19
PS	PCO SIGNED	95JUN08	95JUL30	95SEP21
AM	AWARD MAILED	95JUN18	95AUG09	

LAST PAGE 1

ECP #2

* * PMS BUYING PLAN REPORT FOR * *

95AUG10 OWNED BY: SMC 12:32

PURCH-DESC: ADDITIONAL ALCS WORK STATION					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$274,566	EST-TOT-AMOUNT: $274,566		
EXT-COMP:	C	FOLLOW ON TO COMP ACT	SOL-PROC:	N	OTHER THAN F&O COMP
PROG-STAGE:			SS-CAT:		
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		95MAR20	AGE:	143	CWAM AGE: 142
NETWORK:	M6		SCHEDULED-TIME: 245		
PROGRAM: MEDIUM LAUNCH VEHICLE			KTR: MCDONNELL DOUGLAS CORP		

MILESTONE		SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	95MAR21	95MAR21	95MAR21
ST	ACQ STRATEGY PANEL COMP	95MAY10	95MAY10	95MAR21
SI	SOLICITATION ISSUED	95JUN19	95JUN19	95MAR27
PR	PROPOSALS/BIDS RECEIVED	95AUG18	95AUG18	95APR27
PT	PRICE ANAL/TECH EVAL/AUDT	95OCT17	95OCT17	95MAY02
NC	NEGOTIATIONS COMPLETED	95OCT29	95OCT29	95JUN29
CF	CONTRACT FILE COMPLETED	95OCT06	95OCT06	95AUG01
CW	CONTRACT WRITING COMPLETE	95NOV12	95NOV12	95AUG01
JR	JAG REVIEW COMPLETED	95NOV23	95NOV23	95AUG01
REMARKS: NOT APPLICABLE				
KS	CONTRACTOR SIGNED	95NOV27	95NOV27	95AUG08
PS	PCO SIGNED	95NOV30	95NOV30	95AUG10
AM	AWARD MAILED	95DEC03	95DEC03	

LAST PAGE 1

ECP #3

* * PMS BUYING PLAN REPORT FOR * *

95OCT05 OWNED BY: SMC 12:15

PURCH-DESC: BLOCK IIA LON CAPABILITY					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$3,011,064-	EST-TOT-AMOUNT: $1,324,752-		
EXT-COMP:	C	FOLLOW ON TO COMP ACT	SOL-PROC:	N	OTHER THAN F&O COMP
PROG-STAGE:			SS-CAT:		
SPECIAL-PRO:			ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:		
TYPE-ACT:	DS	DEFIN UNPRICED SUPP AGR	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		94SEP30	AGE:	370	CWAM AGE: 370
NETWORK:	B7		SCHEDULED-TIME: 198		
PROGRAM: MEDIUM LAUNCH VEHICLE			KTR: MCDONNELL DOUGLAS SPACE SYS CO		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
SI	SOLICITATION ISSUED	94SEP30	94SEP30	94SEP30
PR	PROPOSALS/BIDS RECEIVED	95JAN08	95JAN08	94DEC22
FF	FACT FINDING COMPLETED	95JAN29	95JAN29	95MAR17
	DELAY: XX			
	REMARKS: SLOW REVIEW			
FR	FIELD REPORTS RECEIVED	95FEB12	95FEB12	95MAY01
	DELAY: XX			
	REMARKS: SLOW REVIEW			
BA	BUS CLEARANCE APPROVED	95MAR05	95MAR05	95MAY15
	DELAY: XX REFORECAST 95MAY24			
BC	BUS CLEARANCE REQUEST	95MAR05	95MAR05	95MAY15
PT	PRICE ANAL/TECH EVAL/AUDT	95MAR09	95FEB12	95MAY17
PA	PRICING ANALYSIS COMPLETE	95FEB12	95FEB12	95MAY19
TE	TECH EVAL COMPLETED	95FEB12	95FEB12	95MAY19
NC	NEGOTIATIONS COMPLETED	95APR02	95SEP22	95SEP13
	DELAY: XX			
CF	CONTRACT FILE COMPLETED	95MAY28	95SEP29	95SEP22
CW	CONTRACT WRITING COMPLETE	95MAY14	95OCT13	95SEP22
JR	JAG REVIEW COMPLETED	95MAY28	95OCT13	95SEP26
KS	CONTRACTOR SIGNED	95MAY28	95OCT20	95SEP28
AN	AWARD ANNOUNCEMENT - 1279	95MAY28	95OCT27	95SEP28
CS	CONT CLEARANCE APPROVED	95MAY28	95OCT06	95SEP29
PS	PCO SIGNED	95MAY28	95OCT27	95SEP29
AM	AWARD MAILED	95APR16	95OCT28	

UCA INFORMATION

LAST PAGE 1

ECP #4

* * PMS BUYING PLAN REPORT FOR * *

96MAY02 OWNED BY: SMC 11:49

PURCH-DESC: CCP SELF STUDY GUIDE					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$1,053,072	EST-TOT-AMOUNT: $1,053,072		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	A	AWARDED
ACTION-STARTED:		94APR07	AGE:	736	
NETWORK:	M4		SCHEDULED-TIME: 89		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

ACRN	APPROP	YR	BPAC	PEC	OBLIGATED
AE	3020	4	23MLVO	35119F	$1,053,072

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	94APR08	94JUN30	94JUN30
ST	ACQ STRATEGY PANEL COMP	94APR15	95JAN31	94OCT24
SI	SOLICITATION ISSUED	95FEB07	95FEB07	94OCT24
PR	PROPOSALS/BIDS RECEIVED	95FEB16	95FEB16	94DEC14
PT	PRICE ANAL/TECH EVAL/AUDT	95APR14	95AUG11	95MAY01
NC	NEGOTIATIONS COMPLETED	95APR18	95AUG15	95AUG15
	DELAY: XX			
CF	CONTRACT FILE COMPLETED	95APR18	95AUG15	95SEP01
CW	CONTRACT WRITING COMPLETE	95APR18	95AUG15	95SEP06
JR	JAG REVIEW COMPLETED	95APR18	96JAN05	96MAR29
	DELAY: XX			
KS	CONTRACTOR SIGNED	95APR19	96JAN06	96APR04
PS	PCO SIGNED	95APR20	96JAN07	96APR04
AM	AWARD MAILED	95APR22	96JAN09	96APR12

LAST PAGE 1

ECP #5

* * PMS BUYING PLAN REPORT FOR * *

94JUN09 OWNED BY: SMC 13:23

PURCH-DESC: ECP DELETION OF PAYLOAD ENCAPSULATION					
BUYER-CURR:			PCO:		
EST-OBL-AMOUNT:		$0	EST-TOT-AMOUNT: $0		
EXT-COMP:			SOL-PROC:		
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	AFR 70-15 PARA 1-1A
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:	N	NO
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		94FEB01	AGE:	128	
NETWORK:	M4		SCHEDULED-TIME: 89		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

REQUIREMENTS	IDENT	RCVD	PROJECT OFFICE
NONE			

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	94FEB02	94FEB01	94FEB01
ST	ACQ STRATEGY PANEL COMP	94FEB09	94APR13	94FEB01
SI	SOLICITATION ISSUED	94APR13	94APR13	94FEB01
PR	PROPOSALS/BIDS RECEIVED	94APR13	94APR13	94MAR04
PT	PRICE ANAL/TECH EVAL/AUDT	94APR15	94APR15	94APR01
NC	NEGOTIATIONS COMPLETED	94MAY01	94MAY25	94MAY18
CW	CONTRACT WRITING COMPLETE	94MAY10	94JUN03	94MAY31
CF	CONTRACT FILE COMPLETED	94MAY12	94JUN05	94MAY31
JR	JAG REVIEW COMPLETED	94MAY15	94JUN08	94JUN08
KS	CONTRACTOR SIGNED	94MAY17	94JUN10	94JUN09
PS	PCO SIGNED	94MAY18	94JUN11	94JUN09
AM	AWARD MAILED	94MAY19	94JUN12	

LAST PAGE 1

NEW PROCESS
ECP #1

** PMS BUYING PLAN REPORT FOR **

97FEB26 OWNED BY: SMC 12:51

PURCH-DESC: OB GROUND VEHICLE SIMULATOR					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$409,302	EST-TOT-AMOUNT: $409,302		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		96DEC18	AGE:	70	CWAM AGE: 70
NETWORK:	M4		SCHEDULED-TIME: 63		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORPORATION		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	97JAN01	97JAN01	96DEC18
ST	ACQ STRATEGY PANEL COMP	97FEB15	97FEB15	96DEC18
	REMARKS: LAUNCH FAILURE CAUSED DELAY			
SI	SOLICITATION ISSUED	97FEB15	97FEB15	97JAN31
PR	PROPOSALS/BIDS RECEIVED	97MAR15	97MAR15	97FEB14
PT	PRICE ANAL/TECH EVAL/AUDT	97MAR20	97MAR20	97FEB20
NC	NEGOTIATIONS COMPLETED	97APR01	97APR01	97FEB20
AM	AWARD MAILED	97MAY15	97MAY15	

LAST PAGE 1

NEW PROCESS
ECP #2

* * PMS BUYING PLAN REPORT FOR * *

97MAY16 OWNED BY: SMC 18:09

PURCH-DESC:	BO AIR CONDITIONER REPLACEMENT		PCO:		
CURR-BUYER:			PEO-PROG:		
CLERK:			EST-TOT-AMOUNT:	$1,324,034	
EST-OBL-AMOUNT:		$1,324,034	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
EXT-COMP:	A	COMPETED	SS-CAT:	A	FORMAL SS AFFARS APP AA
PROG-STAGE:	P	PRODUCTION	ARPA:		
SPECIAL-PRO:	N	NOT APPLICABLE	FAST-TRK:	D	NOT APPLICABLE
TYPE-CONT:	9	MULTIPLE TYPES	STATUS:	I	IN-PROGRESS
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	AGE:	203	CWAM AGE: 196
ACTION-STARTED:		96OCT25	SCHEDULED-TIME:	63	
NETWORK:	M4		KTR:	MCDONNELL DOUGLAS CORPORATION	
PROGRAM:	MEDIUM LAUNCH VEHICLES III				

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	96NOV01	96NOV01	96NOV01
ST	ACQ STRATEGY PANEL COMP	96NOV01	96NOV01	96NOV01
	REMARKS: CHRISTMAS BREAK AND LAUNCH FAILURE MAY CAUSE DELAY			
SI	SOLICITATION ISSUED	97FEB01	97MAY01	97APR29
	REMARKS: LAUNCH FAIL UCA CAUSED DELAY 01 MAR REVISED DATE			
PR	PROPOSALS/BIDS RECEIVED	97MAR01	97MAY01	97MAY06
	REMARKS: KTR MATERIAL PROBLEMS DELAYING PROPOSAL			
PT	PRICE ANAL/TECH EVAL/AUDT	97MAR05	97MAY05	97MAY08
NC	NEGOTIATIONS COMPLETED	97MAR15	97MAY15	97MAY09
JR	JAG REVIEW COMPLETED	97APR01	97JUN01	97MAY13
CS	CONT CLEARANCE APPROVED	97APR15	97JUN15	97MAY16
PS	PCO SIGNED	97APR16	97JUN16	97MAY16
AM	AWARD MAILED	97MAY01	97JUN27	

LAST PAGE 1

NEW PROCESS
ECP #3

** PMS BUYING PLAN REPORT FOR **

96FEB23 OWNED BY: SMC 14:31

PURCH-DESC: OPS BLDG. EQUIPMENT					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$16,750,884	EST-TOT-AMOUNT: $19,786,825		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		95SEP14	AGE:	162	CWAM AGE: 101
NETWORK:	M4		SCHEDULED-TIME: 63		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	95SEP16	95SEP16	95SEP16
	DELAY: XX DELAY DUE TO SCOPE ISSUES			
ST	ACQ STRATEGY PANEL COMP	95SEP20	95OCT04	95NOV14
	DELAY: XX REENGINEERING PROCESS MILESTONE 1			
SI	SOLICITATION ISSUED	95DEC22	96FEB29	96JAN09
	DELAY: XX REENGINEERING PROCESS MILESTONE 2			
PR	PROPOSALS/BIDS RECEIVED	96JAN15	96MAR24	96JAN30
PT	PRICE ANAL/TECH EVAL/AUDT	96JAN27	96APR05	96JAN30
NC	NEGOTIATIONS COMPLETED	96FEB05	96APR14	96JAN30
CF	CONTRACT FILE COMPLETED	96FEB07	96APR16	96FEB09
CW	CONTRACT WRITING COMPLETE	96FEB11	96APR20	96FEB09
JR	JAG REVIEW COMPLETED	96FEB15	96APR24	96FEB16
KS	CONTRACTOR SIGNED	96FEB18	96APR27	96FEB20
PS	PCO SIGNED	96FEB23	96MAY02	96FEB22
AM	AWARD MAILED	96FEB25	96MAY04	

LAST PAGE 1

NEW PROCESS
ECP #4

* * PMS BUYING PLAN REPORT FOR * *

96AUG06 OWNED BY: SMC 17:47

PURCH-DESC: SUPPLEMENTAL AGREEMENT					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$134,258	EST-TOT-AMOUNT: $134,258		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		96JUL18	AGE:	19	CWAM AGE: 19
NETWORK:	XX		SCHEDULED-TIME: 0		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	96JUL18	96JUL18	96JUL18
ST	ACQ STRATEGY PANEL COMP	96JUL18	96JUL18	96JUL18
SI	SOLICITATION ISSUED	96JUL25	96JUL25	96JUL18
PR	PROPOSALS/BIDS RECEIVED	96JUL26	96JUL26	96JUL18
PT	PRICE ANAL/TECH EVAL/AUDT	96JUL26	96JUL26	96JUL18
NC	NEGOTIATIONS COMPLETED	96JUL29	96JUL29	96JUL29
KS	CONTRACTOR SIGNED	96JUL29	96JUL29	96JUL29
PS	PCO SIGNED	96JUL29	96JUL29	96JUL30
AM	AWARD MAILED	96JUL29	96JUL29	

LAST PAGE 1

NEW PROCESS
ECP #5

* * PMS BUYING PLAN REPORT FOR * *

96SEP24 OWNED BY: SMC 17:20

PURCH-DESC: OB CREDIT MODIFICATION					
CURR-BUYER:			PCO:		
CLERK:			PEO-PROG:		
EST-OBL-AMOUNT:		$561,540-	EST-TOT-AMOUNT: $561,540-		
EXT-COMP:	A	COMPETED	SOL-PROC:	B	F&O COMP- COMP PROPOSAL
PROG-STAGE:	P	PRODUCTION	SS-CAT:	A	FORMAL SS AFFARS APP AA
SPECIAL-PRO:	N	NOT APPLICABLE	ARPA:		
TYPE-CONT:	9	MULTIPLE TYPES	FAST-TRK:	D	NOT APPLICABLE
TYPE-ACT:	SA	SUPPLEMENTAL AGREEMENT	STATUS:	I	IN-PROGRESS
ACTION-STARTED:		96FEB17	AGE:	220	CWAM AGE: 207
NETWORK:	M5		SCHEDULED-TIME: 154		
PROGRAM: MEDIUM LAUNCH VEHICLES III			KTR: MCDONNELL DOUGLAS CORP		

	MILESTONE	SCHEDULE	FORECAST	ACTUAL
RI	REQUIREMENT IDENTIFIED	96FEB19	96FEB19	96FEB20
ST	ACQ STRATEGY PANEL COMP	96MAR04	96MAR04	96MAR01
SI	SOLICITATION ISSUED	96MAR12	96MAR12	96JUL20
PR	PROPOSALS/BIDS RECEIVED	96APR05	96APR05	96AUG01
PT	PRICE ANAL/TECH EVAL/AUDT	96MAY13	96MAY13	96AUG10
NC	NEGOTIATIONS COMPLETED	96JUN15	96JUN15	96AUG20
CF	CONTRACT FILE COMPLETED	96AUG23	96AUG23	96AUG30
CW	CONTRACT WRITING COMPLETE	96AUG26	96AUG26	96SEP04
KS	CONTRACTOR SIGNED	96AUG30	96AUG30	96SEP20
PS	PCO SIGNED	96SEP04	96SEP04	96SEP23
AM	AWARD MAILED	96JUL20	96SEP09	

LAST PAGE 1

APPENDIX B

PERT ANALYSIS OF RE-ENGINEERED CONTRACT CHANGE PROCESS

PERT Analysis of Re-Engineered Contract Change Process

Examination will focus on the information that is kept in a central contracting database called AMIS. This database is used to keep track and record the progress of ECP's as they move through the contracting process. There are very specific milestones that must be reached for each ECP to be put on contract. These are the milestones that are tracked in the database and the ones that will be used in the PERT analysis as the specific activities.

Old Process

Activity			ECP #1	ECP #2	ECP #3	ECP #4	ECP #5	T(2) (Average)
RI	Requirement Identified		–	–	–	–	–	–
ST	Acq Strategy Panel Comp		1	0	–	16.57	0	3.51
SI	Solicitation Issued		3.14	1	–	0	0	0.83
PR	Proposals/Bids Received		4.14	4.43	12	7.29	4.43	6.46
PT	Price Anal/Tech Eval/Audit		10.57	0.71	20.57	19.71	4	11.11
NC	Negotiations Completed		14.14	8.29	17.29	15.14	6.71	12.31
CF	Contract File Complete		7.14	4.71	1.29	2.43	2	3.51
CW	Contract Writing Complete		0.57	0	0	0.71	0	0.26
KS	Contractor Signed		3.14	1	0.29	0.86	0.14	1.09
JR	JAG Review Completed		5	–	0.57	29.29	1.14	7.20
PS	PCO Signed		0.29	0.29	0.43	0	0	0.20
		Total Time	49.13	20.43	52.44	92	18.42	46.48
		Value	$800,029	$274,566	$1,324,752	$1,053,072	$0	$690,484
		Designator	3rd Stage PC	ALCS W/S	LON	SSG	Payload	

New Process

Activity			ECP #1	ECP #2	ECP #3	ECP #4	ECP #5	T(2) (Average)
RI	Requirement Identified		–	–	–	–	–	–
ST	Acq Strategy Panel Comp		0	0	8.57	0.29	1.29	2.03
SI	Solicitation Issued		6.29	25.57	8	0.29	10	10.03
PR	Proposals/Bids Received		2	1	3	0.29	3	1.86
PT	Price Anal/Tech Eval/Audit		1	0.29	0	0.29	1.29	0.57
NC	Negotiations Completed		0	0.14	0	1.86	1.43	0.69
CF	Contract File Complete		0	0	1.43	0.43	1.43	0.66
CW	Contract Writing Complete		0	0	0	0	0.71	0.14
KS	Contractor Signed		0	0	0.57	0	2.29	0.57
JR	JAG Review Completed		–	0.57	1	–	–	0.31
PS	PCO Signed		0	0.43	0.29	0.14	0.43	0.26
		Total Time	9.29	28	22.86	3.59	21.87	17.12
		Value	$409,302	$1,324,034	$19,786,825	$134,258	$561,540	$4,443,192
		Designator	GVS	A/C	OB	R-Size	OB Credit	

T(1) (Streamlined)	T(3) (Worst Case)	Expected	Std. Dev.	Earliest Start	Latest Start	Earliest Finish	Latest Finish	Slack	Critical Path?
–	–	–	–	–	–	–	–	–	Y
0	16.57	5.1	2.76	0.0	0.0	5.1	5.1	0.0	Y
0	3.14	1.1	0.52	5.1	5.1	6.2	6.2	0.0	Y
4.14	12	7.0	1.31	6.2	10.2	13.2	17.2	4.0	
0.71	20.57	11.0	3.31	6.2	6.2	17.2	17.2	0.0	Y
6.71	17.29	12.2	1.76	17.2	17.2	29.4	29.4	0.0	Y
1.29	7.14	3.7	0.98	29.4	29.4	33.1	33.1	0.0	Y
0	0.71	0.3	0.12	29.4	32.8	29.7	33.1	3.4	
0.14	3.14	1.3	0.50	33.1	33.1	34.4	34.4	0.0	Y
1.14	29.29	9.9	4.69	6.2	23.2	16.1	33.1	17.0	
0.2	0.43	0.2	0.07	34.4	34.4	34.6	34.6	0.0	Y

T(1) (Streamlined)	T(3) (Worst Case)	Expected	Std. Dev.	Earliest Start	Latest Start	Earliest Finish	Latest Finish	Slack	Critical Path?
–	–	–	–	–	–	–	–	–	Y
0	8.57	2.8	1.43	0.0	8.2	2.8	11.0	8.2	
0.29	25.57	11.0	4.21	0.0	0.0	11.0	11.0	0.0	Y
0.29	3	1.8	0.45	11.8	11.8	13.6	13.6	0.0	Y
0	1.29	0.6	0.22	11.0	11.2	11.6	11.8	0.2	
0	1.86	0.8	0.31	11.0	11.0	11.8	11.8	0.0	Y
0	1.43	0.7	0.24	13.6	13.6	14.3	14.3	0.0	Y
0	0.71	0.2	0.12	11.0	11.6	11.2	11.8	0.6	
0	2.29	0.8	0.38	14.3	14.3	15.1	15.1	0.0	Y
0.57	1	0.5	0.07	11.0	13.8	11.5	14.3	2.8	
0.26	0.43	0.2	0.07	15.1	15.1	15.3	15.3	0.0	Y

ACQUISITION REVIEW QUARTERLY GUIDELINES FOR CONTRIBUTORS

The *Acquisition Review Quarterly (ARQ)* is a scholarly peer-reviewed journal published by the Defense Acquisition University. All submissions receive a masked review to ensure impartial evaluation.

SUBMISSIONS

Submissions are welcomed from anyone involved in the Defense acquisition process. Defense acquisition is defined as the conceptualization, initiation, design, development, test, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services to satisfy Defense Department needs, or intended for use in support of military missions.

RESEARCH ARTICLES

Manuscripts should reflect research or empirically-supported experience in one or more of the aforementioned areas of acquisition. Research or tutorial articles should not exceed 4,500 words. Opinion pieces should be limited to 1,500 words.

We publish Defense Acquisition research articles that involve systemic inquiry into a significant research question. The article must produce a new or revised theory of interest to the acquisition community. You must use a reliable, valid instrument to provide your measured outcomes.

MANUSCRIPT SECTIONS

The introduction should state the purpose of the article and concisely summarize the rationale for the undertaking.

The methods section should include a detailed methodology that clearly describes work performed. Although it is appropriate to refer to previous publications in this section, the author should provide enough information so that the experienced reader need not read earlier works to gain understanding of the methodology.

The results section should concisely summarize findings of the research and follow the train of thought established in the methods section. This section should not refer to previous publications, but should be devoted solely to the current findings of the author.

The discussion section should emphasize the major findings of the study and its significance. Information presented in the aforementioned sections should not be repeated.

RESEARCH CONSIDERATIONS

Contributors should also consider the following questions in reviewing their research-based articles prior to submission:

- Is the research question significant?
- Are research instruments reliable and valid?
- Are outcomes measured in a way clearly related to the variables under study?
- Does the research design fully and unambiguously test the hypothesis?
- Did you build needed controls into the study?

Contributors of research-based submissions are also reminded they should share any materials and methodology necessary to verify their conclusions.

CRITERIA FOR TUTORIALS

Tutorials should provide special instruction or knowledge relevant to an area of defense acquisition to inform the Defense Acquisition Workforce.

Topics for submissions should rely on or be derived from observation or experiment, rather than theory. The submission should provide knowledge in a particular area for a particular purpose.

OPINION CRITERIA

Opinion articles should reflect judgments based on the special knowledge of the expert. Opinion articles should be based on observable phenomena and presented in a factual manner; that is, submissions should imply detachment. The observation and judgment should not reflect the author's personal feelings or thoughts. Nevertheless, opinion pieces should clearly express a fresh point of view, rather than negatively criticize the view of another previous author.

MANUSCRIPT STYLE

We will require you to recast your last version of the manuscript, especially citations (e.g., footnotes or endnotes) into the format required in two specific style manuals. The ARQ follows the author (date) form of citation. We expect you to use the Publication Manual of the American Psychological Association (4th Edition), and the Chicago Manual of Style (14th Edition). The ARQ follows the author (date) form of citation.

Contributors are encouraged to seek the advice of a reference librarian in completing citations of government documents. Standard formulas of citations may give only incomplete information in reference to government works. Helpful guidance is also available in Garner, D.L. and Smith, D.H., 1993, The Complete Guide to Citing Government Documents: A Manual for Writers and Librarians (Rev. Ed.), Bethesda, MD: Congressional Information Service, Inc.

COPYRIGHT INFORMATION

The *ARQ* is a publication of the United States Government and as such is not copyrighted. Contributors of copyrighted works and copyright holders of works for hire are strongly encouraged to request that a copyright notification be placed on their published work as a safeguard against unintentional infringement. The work of federal employees undertaken as part of their official duties is not subject to copyright.

In citing the work of others, it is the contributor's responsibility to obtain permission from a copyright holder if the proposed use exceeds the fair use provisions of the law (see U.S. Government Printing Office, 1994, Circular 92: Copyright Law of the United States of America, p. 15, Washington, DC: Author). Contributors will be required to submit a copy of the written permission to the editor before publication.

MANUSCRIPT FORMAT

Pages should be double-spaced and organized in the following order: title page, abstract, body, reference list, author's note (if any), and figures or tables. To ensure anonymity, each paper should be submitted with a separate page that includes the author(s)'s name(s) and complete address, and the paper should include the title, abstract, keywords, body, complete set of references, along with tables and figures at the end. Authors are reminded not to refer to themselves or to their own work directly in the paper. Figures or tables should not be inserted (or embedded, etc.) into the text, but segregated one to a page following the text. Articles must be printable within one issue and should not exceed 4,500 words for research or tutorials and 1,500 words for opinion pieces; articles will not be printed in parts or in a continuing series. If material is submitted on a computer diskette, each figure or table should be recorded in a separate, exportable file (i.e., a readable .eps file). For additional information on the preparation of figures or tables, see CBE Scientific Illustration Committee, 1988, Illustrating Science: Standards for Publication, Bethesda, MD: Council of Biology Editors, Inc. Please restructure briefing charts and slides to a look similar to those in previous issues of ARQ.

The author (or corresponding author in the case of multiple authorship) should attach to the manuscript a signed cover letter that provides the author's name, address, and telephone number (fax and Internet addresses are also appreciated). The letter should verify that the submission is an original product of the author; that it has not been published before; and that it is not under consideration by another publication. Details about the manuscript should also be included in this letter: for example, its title, word length, the need for copyright notification, the identification of copyrighted material for which permission must be obtained, a description of the computer application programs and file names used on enclosed diskettes, etc.

The letter, one copy of the printed manuscript, and any diskettes should be sturdily packaged and mailed to: Defense Systems Management College, Attn: DSMC Press (*ARQ*), 9820 Belvoir Road, Suite 3, Fort Belvoir, VA 22060-5565.

In most cases, the author will be notified that the submission has been received within 48 hours of its arrival. Following an initial review, submissions will be referred to referees and subsequent consideration by the *ARQ* Editorial Board.

Contributors may direct their questions to the Editor, *ARQ*, at the address shown above, by calling (703) 805-4290 (fax 805- 2917), or via the Internet at:

gonzalezd@dsmc.dsm.mil.

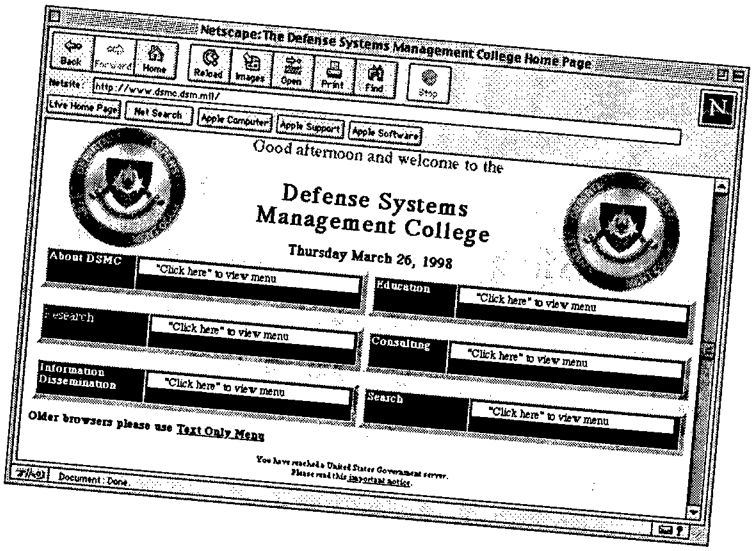
The DSMC Home Page can be accessed at:

http://www.dsmc.dsm.mil.

DSMC'S Home Page

http://www.dsmc.dsm.mil

Your Online Access to Acquisition Research, Consulting, Information, and Course Offerings



On DSMC Home Page Now...

About DSMC

- Commandant's Welcome
- DSMC Information
- Executive Institute
- DSMC Education
- General Student Information
- Getting to Ft. Belvoir
- News and Events

Research

- David D. Acker Library
- Acquisition Related Events
- Best Practices
- Lessons Learned
- Overview/Projects
- ROAR
- Information Dissemination
- Related Links
- Publications
- Services

Education

- Academic Programs Division
- Course Catalog
- Division of College Administration and Services (DCAS)
- Divisions/Faculty Departments
- DSMC Alumni
- DSMC Course List
- The Executive Program Manager's Course (EPMC)
- Access to the EPMC Intranet
- Learning Resource Center
- Program Management
- Regional Centers
- Registrar

Consulting

- The Cost Analysis Strategy Assessment (CASA) model
- Expertise List
- Management Deliberation Center (MDC)/Group Services
- Consulting Services

Now you can Search the DSMC Website and our on-line Publications!

PROGRAM MANAGER SUBSCRIPTION

Order Processing Code:
*5456

Superintendent of Documents
Subscription Order Form

Charge your order. It's easy!
MasterCard VISA
To fax your orders (202) 512-2250

☐ **YES,** please send me ____ subscription(s) to the Program Manager, Journal of the Defense Systems Management College, (PROM) at $14.00 each per year.

The total cost of my order is $________. Price includes regular shipping and handling and is subject to change. International customers, please add 25%.

Company or personal name (Please type or print)

Additional address/attention line

Street address

City, State, Zip code

Daytime phone including area code

Purchase order number (optional)

For privacy, check box below:
☐ Do not make my name available to other mailers

Check method of payment:
☐ Check payable to Superintendent of Documents
☐ GPO Deposit Account ☐☐☐☐☐☐☐ – ☐
☐ VISA ☐ MasterCard ☐☐☐☐ (expiration date)

Thank you for your order!

Authorizing Signature 1/96

Mail to: Superintendent of Documents
P.O. Box 371954, Pittsburgh, PA 15250-7954

☐ **Change of address only.**

ARQ SUBSCRIPTION

FREE SUBSCRIPTIONS
ACQUISITION REVIEW QUARTERLY (ARQ)

CHANGE OF ADDRESS

☐ **Change of address only.**
☐ Please add my name to your free subscription list.

Name and Title

Organization

Address

City State Zip ( ) Daytime Phone

FEDERAL EMPLOYEES Can Receive a Free Subscription to

PROGRAM MANAGER (PM) and/or ACQUISITION REVIEW QUARTERLY (ARQ)

I am a federal employee (military or civilian) and want to add my name to your free subscription list.

PM ☐
ARQ ☐
BOTH ☐
Change of address only ☐

Name and Title

Organization

Address

City State Zip ( ) Daytime Phone

AFFIX
POSTAGE
HERE

SUPERINTENDENT OF DOCUMENTS
P.O. BOX 371954
PITTSBURGH, PA 15250–7954

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 12 FORT BELVOIR, VA

POSTAGE WILL BE PAID BY ADDRESSEE

DEPARTMENT OF DEFENSE
DEFENSE SYST MGMT COLLEGE
ATTN DSMC PRESS
9820 BELVOIR ROAD
SUITE 3
FT BELVOIR VA 22060-9989

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 12 FORT BELVOIR, VA

POSTAGE WILL BE PAID BY ADDRESSEE

DEPARTMENT OF DEFENSE
DEFENSE SYST MGMT COLLEGE
ATTN DSMC PRESS
9820 BELVOIR ROAD
SUITE 3
FT BELVOIR VA 22060-9989

RENEW *ARQ* NOW!

The U.S. postal regulations require that if you receive a free subscription for *ARQ*, and wish to continue doing so, you must sign, date and return this form no later than **May 30, 1999**. Also, please answer a few questions. Remove the pressure-sensitive label from the publication's cover and place it on the form's designated spot. Make address corrections directly on the label. After signing, dating, and providing information, fold the form so the business reply's mailing address is visible; tape it closed (PLEASE DO NOT STAPLE), and drop it in the mail or fax it to (703) 805-2917. If you do not respond, you will be dropped from our mailing list. This update will keep your subscription current through May 2002.

YES! I (or my office) would like to continue receiving the *Acquisition Review Quarterly*.

____

(Signature and Date)

PLEASE PLACE ADDRESS LABEL HERE

STATUS (OFFICE OR INDIVIDUAL), CHECK ONE:

DoD Civilian	**Military**	**Other**
❑ OSD	❑ Army	❑ Industry
❑ Army	❑ Navy	❑ Academia
❑ Navy	❑ Air Force	❑ Library (Ind., Acad., Govt.)
❑ Air Force	❑ Marine Corps	❑ Complimentary
❑ Marine Corps	❑ Non-DoD Government	❑ Other

DSMC GRADUATES PLEASE CHECK APPROPRIATE BOX(ES):
(Use course # or acronym)

❑ PMC/APMC Class ________________________ (ex., APMC 98-1)

❑ Executive Course(s)________________________ (ex., EPMC 98-1)

❑ Short Course(s) ________________________ (ex., ACQ101 98-1)